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THE
UNIVERSITY OF COLORADO
STUDIES

VOL. VII

FRANCIS RAMALEY
EDITOR

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DECEMBER, 1909, TO JUNE, 1910

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CONTENTS OF VOLUME VII

NO. 1

	PAGE
1. FREIGHT RATES AND MANUFACTURES IN COLORADO. A CHAPTER IN ECONOMIC HISTORY	5
JOHN BURTON PHILLIPS, PH.D. Professor of Economics and Sociology	
2. FOREIGN DRAMA ON THE ENGLISH AND AMERICAN STAGE. II. GERMAN DRAMA	63
CHARLES C. AYER, PH.D. Professor of Romance Languages	
3. BORROWINGS AND ADAPTATIONS FROM THE "ILIAD" AND "ODYSSEY" IN MATTHEW ARNOLD'S "SOHRAB AND RUSTUM"	73
MILO G. DERHAM, PH.D. Assistant Professor of Latin	
4. THE UNIVERSITY OF COLORADO MOUNTAIN LABORATORY	91
FRANCIS RAMALEY, PH.D. Professor of Biology	

NO. 2

1. THE DECLINING BIRTHRATE	159
JOHN BURTON PHILLIPS, PH.D. Professor of Economics and Sociology	
2. AN INTRODUCTION TO THE STUDY OF ROCKY MOUNTAIN BEES	179
T. D. A. COCKERELL Professor of Systematic Zoölogy and W. W. ROBBINS, M.A. Instructor in Biology	

NO. 3

SCIENTIFIC EXPEDITION TO NORTHWESTERN COLORADO IN 1909	
1. ITINERARY, TOPOGRAPHY AND GEOLOGY	101
JUNIUS HENDERSON, B.A. Curator of the Museum	

2. REMARKS ON THE CLIMATOLOGY OF NORTHWESTERN COLORADO 112
 W. W. ROBBINS, M.A.
 Instructor in Biology
3. A BOTANICAL TRIP IN NORTHWESTERN COLORADO 115
 W. W. ROBBINS, M.A.
 Instructor in Biology
4. MOLLUSCA COLLECTED IN NORTHWESTERN COLORADO IN 1909 125
 JUNIUS HENDERSON, B.A.
 Curator of the Museum
5. SOME INSECTS COLLECTED IN NORTHWESTERN COLORADO IN 1909 126
 T. D. A. COCKERELL
 Professor of Systematic Zoölogy
6. REPTILES AND AMPHIBIANS OF THE UNIVERSITY OF COLORADO EXPEDITION OF 1909 130
 T. D. A. COCKERELL
 Professor of Systematic Zoölogy
7. NOTES ON BIRDS AND MAMMALS OF NORTHWESTERN COLORADO 132
 A. H. FELGER
8. FOSSIL INVERTEBRATES FROM NORTHWESTERN COLORADO 146
 JUNIUS HENDERSON, B.A.
 Curator of the Museum
9. FOSSIL PLANTS FROM THE MESA VERDE CRETACEOUS 149
 T. D. A. COCKERELL
 Professor of Systematic Zoölogy
10. BIBLIOGRAPHY OF PAPERS DEALING WITH THE GEOLOGY AND NATURAL HISTORY OF NORTHWESTERN COLORADO 151

No. 4

- | | | |
|----|---|-----|
| 1. | PRE-THAESIAN PHILOSOPHY | 201 |
| | MELANCHTHON F. LIBBY, PH.D.
Professor of Philosophy | |
| 2. | SEX DIFFERENCES AND VARIABILITY IN COLOR PERCEPTION | 207 |
| | V. A. C. HENMON, PH.D.
Professor of Psychology | |
| 3. | INTRODUCTION TO THE STUDY OF THE ANTS OF NORTHERN
COLORADO | 215 |
| | W. W. ROBBINS, M.A.
Instructor in Biology | |
| 4. | REMARKS ON SOME NORTHERN COLORADO PLANT COMMUNITIES
WITH SPECIAL REFERENCE TO BOULDER PARK (TOLLAND,
COLO.) | 223 |
| | FRANCIS RAMALEY, PH.D.
Professor of Biology | |
| 5. | NOTES ON THE FLOW OF WATER IN IRRIGATION DITCHES | 237 |
| | CLEMMENT C. WILLIAMS, C.E.
Associate Professor of Civil Engineering | |
| 6. | ALPHABETICAL INDEX | 249 |

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CONTENTS

	PAGE
1. FREIGHT RATES AND MANUFACTURES IN COLORADO. A CHAPTER IN ECONOMIC HISTORY	5
JOHN BURTON PHILLIPS, PH.D. Professor of Economics and Sociology	
2. FOREIGN DRAMA ON THE ENGLISH AND AMERICAN STAGE. II. GERMAN DRAMA	63
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4. THE UNIVERSITY OF COLORADO MOUNTAIN LABORATORY	91
FRANCIS RAMALEY, PH.D. Professor of Biology	

FREIGHT RATES AND MANUFACTURES IN COLORADO: A CHAPTER IN ECONOMIC HISTORY

BY JOHN BURTON PHILLIPS

CONTENTS

CHAPTER I. INTRODUCTION	PAGE
Denver as a Distributing Centre	9
Importance of Long Haul	9
Dependence of Rocky Mountain Region on Railroads	9
Power of Railroad Manager	10
Interest of Railroad Manager in Dividends	10
Carrying Industry Desires Haulage	10
Localization of Manufactures in East Increases Haulage	10
Manufactures in East; Raw Material Production in West	11
Transportation Companies' Interest in This Condition	11
Population Moves West More Rapidly than Manufactures	11
Heaviest Denver Shippers Formulated First Schedule of Freight Rates	11
This Schedule Accepted by Railroad	12
Industrial Characteristics of Mining Population	12
Beginning of Local Manufacture	13
Complaints against the Freight Rates	13
Legislative Investigation of 1885	14
CHAPTER II. TESTIMONY OF MANUFACTURERS AND MERCHANTS	
<i>Paper.</i> —Paper-Mill Project Defeated by Threat to Lower Rates	15
<i>Saddlery.</i> —Rate on Raw Material Higher than on Manufactured Goods	15
Freight Rate Lower from East through Denver to California than to Denver	16
Lower Rates to Cheyenne and Ogden than to Denver	17
Whip Manufacture Discouraged by High Rates	18
Evils of Railroad Pool	18

Alleged Railroad Freight Inspector	18
Rebating System and Its Effects	19
<i>Matches.</i> —Manufacture Begun but Discouraged by Rates	20
Monopoly of Diamond Match Company	20
<i>Soap.</i> —Rates Discouraged Maunfacture	20
Kirk and Company's Monopoly	21
<i>Iron.</i> —Early Development of Iron Manufacture Needed in Mining Region	22
Freight Rates Same on Raw Material and Manufactured Articles	23
Discrimination against Denver as Distributing Point	25
<i>Powder.</i> —Reduction in Price after Erection of Denver Mill	27
Combination of DuPont Monopoly with Railroads	27
<i>Glass.</i> —Railroad Threat to Lower Rate on Incoming Glass	28
Operation of Factory Raised Denver Rates to Tributary Points	29
<i>Carriages.</i> —Rate on Materials Higher than on Manufactured Article	30
<i>Building Material and Furniture. Boxes. Brooms.</i> —Rate Same on Unfinished and Finished Furniture	31
Rate on Mattresses Favored Manufacturer at Missouri River	33
<i>Cement and Terra Cotta.</i> —Difficulty in Distribution of Product	34
<i>Groceries.</i> —Table of Discriminatory Rates	36
<i>Coal Mining.</i> —Complaints of Coal Mine Operators	38
Railroads Engaged in Coal Mining	39
Monopoly Price Discouraged New Manufacturers	40

CHAPTER III. TESTIMONY OF RAILROAD OFFICIALS

Santa Fe Discriminated against Goods Made in Colorado	41
Higher Rates from Denver than from Missouri River	41
Rio Grande Favored Colorado Consumer Rather than Manufacturer	42
Nail Rate Reduced to Favor Colorado Coal and Iron Co.	43
Origin of Colorado Coal and Iron Co. Railroad Assistance	44
Attitude of Union Pacific	45
Pressure on Railroads by Eastern Manufacturers	45
Letter of Pool Commissioner Promising Aid to Manufacturers	48

CHAPTER IV. 1885-1896

Law Creating Railroad Commissioner and Its Repeal	49
Complaints against Freight Rates by Presidents of Denver Chamber of Commerce	49

Freight Rate Attack on Paper-Mill	50
Resolution of Citizens' League against Freight Rates	51
Table of Commodity Rates to Colorado and California	52
Table of Commodity Rates, California to Colorado and Missouri River	54
Table of Distributive Rates from Colorado	54
Discrimination in Favor of Missouri River Points	55
Peculiarities of Rate Discrimination	56
Difficulties of Colorado Jobbers	57
Discrimination against Mattress Manufacture	59
Discrimination against Iron Manufacture in Pueblo	60
Inter-State Commerce Commission's Order to Reduce Rate on Iron	61
Commission's Order Vacated by United States Circuit Court	61
Failure of Denver to Secure Missouri River Commodity Rates	61

FREIGHT RATES AND MANUFACTURES IN COLORADO

CHAPTER I. INTRODUCTION

The geographical situation of the city of Denver and its function as the distributing centre of the Rocky Mountain region have made the question of transportation of paramount importance. Denver is 1,000 miles from Chicago and 1,800 from San Francisco. It is also about 1,000 miles from the Gulf points and 1,700 from Seattle. From Missouri River points the distance is 600 miles. It thus appears that the city is the only largely populated centre within a vast territory. Further, the entire region between the Missouri River and the Rocky Mountains is not densely populated. Local traffic is therefore not important and the feature that has appeared most decisive to the railroad companies has always been the long haul. When the Pacific Railroad was opened in 1867, it was supposed that Cheyenne would be the future metropolis of the Rocky Mountain region and little attention was paid by the railroads to the thought of building a road from the Union Pacific southward to Denver, then a town of some 4,000 inhabitants. It must be remembered that the gold craze which was so powerful a factor in filling Colorado with population in the years immediately following 1859 had spent its force and thousands of the disappointed gold hunters had returned to their homes in the east.

The men who had stayed in Colorado knew the value of the region as a mining state and, with a thorough belief in the future, sought to secure railroad connection with the outside world. They began at once to raise the funds necessary for building a railroad from Cheyenne to Denver, and after many disappointments and difficulties, the road was opened for traffic on June 22, 1870. The road was built purely by local enterprise. By September of the same year another railroad, the Kansas Pacific, reached the city and thus Denver had satisfactory communication with the outside world and by two different routes.

The history of no city shows more clearly the immense power of the railroad managers over the growth and development not only of cities

but also of large sections of the country. As already indicated the geographical situation of the city and the country tributary to it were in great degree absolutely dependent upon the freight rate for any reasonable growth. Water communication which has guaranteed fair rates to so many places did not exist; navigation of the air was not possible; haulage by wagon was so expensive that it was prohibitory for all except the most valuable kinds of freight. The Rocky Mountain region was therefore absolutely dependent upon the mercies of the railroad manager.

The history of railroading in the United States shows clearly enough that the railroad manager is guided in his action by the interests of the men that own the railroad. The men that build and operate a railroad are entitled to make a profit out of their work and hence it happens that the manager is primarily interested in what dividends he is able to secure. Railroads are built for the purpose of hauling commodities primarily and anything that tends to make communities self-sufficient and thus eliminate the need of transporting goods to them is not likely to receive aid and support from the men who have invested their money in and are devoting their energies to railroads. If each community in the United States began in considerable measure to manufacture the things that are consumed in that particular section, and if the raw materials of manufacture were not required to be hauled in, it is at once apparent that there would be some diminution in the amount of freight carried by the railroads that are now serving these places in the capacity of carriers. It is therefore to the interest of the carrying industry that manufactures should not spread over all sections of the United States. In the railroad manager's point of view, it is more to his financial interest to have manufactures largely localized in the eastern part of the country and to keep the West engaged in the production of raw materials. By accomplishing this, he will be able to furnish enormous traffic for the carrying industry. He will haul the manufactured goods from the East to the raw material producing regions of the West and vice versa. This will greatly increase his profits as long as the industries remain thus localized. This brings to mind the navigation laws of the seventeenth century and the prohibition of manufactures that preceded the revolutionary war. The interest of the mother country was to keep the colonies raw material producing

regions, and in modern times the East and the railways have had the same interest in preventing the growth of manufactures in the western states. That this interest has been in some degree effective appears by a study of the increase of population and the movement of manufactures toward the West in the United States.

From 1850 when the domestic system of manufacture gave way to the factory, the progress of manufacture toward the West has not kept pace with the westward movement of population. In 1850, the centre of manufactures was a little south of the middle of Pennsylvania, slightly north and west of Harrisburg, while the centre of population was just west of the eastern boundary line of Maryland, being thus considerably east of the centre of manufactures. By 1900, the centre of population had moved westward to a point almost south of Indianapolis while the centre of manufactures was a little east of a line from Columbus to Toledo. During the same period manufactures increased from \$1,000,000,000 in 1850 to \$13,000,000,000 in 1900. This shows a marked concentration in the manufacturing industry.

On June 23, 1870, the next day after the first locomotive arrived in Denver, there was a meeting of the heaviest shippers to consider the matter of freight rates. On the following day another meeting of the same persons was held and a schedule of rates was agreed upon. This schedule was presented to the superintendent of the railroad who replied on June 28 as follows:

DENVER PACIFIC RAILWAY
Superintendent's Office

Denver Colo., June 28, 1870

Fred. Z. Solomon, Esq., Chairman Business Men's Meeting, Denver, Colo.

SIR: The proceedings of the meetings of the heaviest shippers of this place, held in this city June 23 and 24, were handed me by your secretary, Mr. McDonald. The recommendations of the meetings were presented by me to the proper railroad officials, and the rates proposed by your meetings for carrying freights have been adopted and will be published in a few days. These rates will apply to all freight which has come into Denver over the Denver Pacific Railway since June 25, and if any other rate has been paid, the matter will be properly adjusted upon application to me at this office.

Very respectfully,

Your obedient servant,

C. W. FISHER,
Supt. D. P. R. R.

In reply to this the committee having the matter in charge adopted the following resolution:

Resolved, That the reply of Col. Fisher to the request of the shippers of Denver relative to freight tariff over the road of which he is superintendent is perfectly satisfactory, and our thanks are due for the prompt and cheerful compliance with our request.

FRED Z. SOLOMON, *Chairman*.

F. A. McDONALD, *Secretary*.

After publishing this correspondence, the editor of the *Colorado Daily Tribune* remarked that this was an auspicious beginning as it proved that the railroad company and the merchants were dwelling together in unity. He thought this was a forerunner of what might be expected in the future.¹

It is true that this looked like an auspicious beginning but there were certain conditions that made it to the interest of the railroads apparently to keep the prices for transporting freight to Colorado high. The roads had been built in advance of the needs of the time. There was no population along their line to furnish them with any business. If their stock was to become at all valuable, they must do their utmost to secure as large a revenue as possible from all shippers who patronized them. Therefore, there was every inducement for them to raise the rates and keep them high. There was also the inducement to keep new manufactures from locating in Colorado so as to supply the home market. This would reduce the revenue of the roads from hauling in freight.

There was also another cause operating to prevent freight rates favorable to the establishment of manufactures and that was the leading occupation of the country. Manufacturing is a routine industry; it takes time and patience and does not furnish the opportunity to "strike it rich" suddenly. Wealth made in manufacturing comes slowly as the result of years of patient attention and devotion to the details of the business and to the development of a large market by advertising and so forth. This industry, therefore, requires a different type of mind from that needed in such an industry as mining. After the railroad had reached Denver, the people that came for the next ten years or more were very largely persons interested in one way or another in the mining

¹ *Colorado Daily Tribune*, June 29, 1870.

development of the state. They did not come to Colorado for the purpose of starting a manufacturing plant. In fact, the rewards from the mining industry had become sufficiently well known to make most of the migrating population turn their energies in that direction rather than pay much attention to the establishment of manufactures. The persons, then, that came to the state in the earlier decades were persons of the adventurous type of mind and not persons accustomed to the monotonous routine of workaday industry. A population of this sort largely engaged in the mining industry expects that everything will be high. A mining region is accustomed to pay high prices for all things as the rewards of industry in the search for gold are apt to be high and this increases the cost of all other things as workers in other lines must be paid as much as the average returns of the gold seeker. If they are not so paid they will also engage in the search for the precious metals.

This was the situation in Colorado for the first decade and more after the railroad reached Denver. Mining was the leading occupation. No one was paying much attention to manufacturing; the returns from mining were sufficiently large to make that the paramount industry. Therefore the few manufacturing concerns which did start were soon disposed of by the adjustment of discriminatory rates on the part of the railroad companies. After the factories started, the rates were lowered so that goods could be brought in from the East more cheaply than they could be produced in Denver. This matter did not attract any particular attention during the early period as mining was occupying too prominent a place. As Denver increased in population, however, and it was seen that it was destined to be one of the large cities of the country, and as it also became apparent that the cheaper forms of mining were no longer efficient, then it was evident that manufacturing in Colorado would be an advantage to the city and state. Therefore, public attention began to be directed toward whatever hindrances there were to the development of this important industry. The freight rate difficulty was at once complained of. Discussion of the injustice which it was alleged the city and state were suffering at the hands of the railroads was carried on in the newspapers and in January, 1885, the legislature, almost immediately after convening, appointed a special railroad com-

mittee of the house of representatives to investigate the freight rate situation and ascertain if possible whether or not the railroads were unfavorable to the establishment of manufactures in Colorado. This committee occupied several weeks in examining witnesses, both shippers and railroad agents and officers, in an honest endeavor to ascertain the facts of the existing situation and also the attitude of the railroads toward the establishment of manufacturing industries in Colorado. Much important testimony was taken and great light was thereby thrown upon many phases of the question. From this testimony important data bearing on the relation of the freight rate to manufactures has been summarized below.

CHAPTER II. TESTIMONY OF MANUFACTURERS AND MERCHANTS

PAPER

In 1884, a plan was matured to build a paper-mill in Denver. Mr. Woodworth, a gentleman who was familiar with the manufacture of paper in the East and who had been spending the summer in Colorado, saw the possibilities in the manufacture of paper in the city and decided to set up a mill. He convinced some of the local capitalists that the enterprise would pay. A lot was selected and he went East to buy the necessary machinery. The capital of the establishment was to be \$250,000. When the railroad officials learned of the scheme they informed Mr. Woodworth that in case a paper-mill was started in Denver they would put the freight rates on incoming paper so low that he could not afford to manufacture.¹

SADDLERY AND HARDWARE

Mr. E. B. Light who was engaged in the saddlery business in Denver in 1885 explained to the committee the effect of the freight rates on leather manufacture. It appears from his testimony that the rate on raw material was generally higher than on manufactured goods. There was at that time a combination in the saddlery hardware business and the trust would lay down the same hardware any place east of the Mississippi River at the same price. The dealer at the River got the goods therefore at the price paid by the dealer in Newark, N. J. The freight on one hundred dollars worth of such hardware from the Missouri River to Denver was about one fourth of the value, so that the Denver dealer had to pay \$125 for what the dealer at the River secured for \$100.² The same rate on raw and manufactured goods was a loss to the railroad according to Mr. Light as the amount of money invested in a harness if invested in the raw material and this shipped in from the River would yield a large amount in freight as the raw material was three or four times as heavy as the finished product. This was true of either leather

¹ *Evidence, Special Railroad Committee*, pp. 13, 14, 1885.

² *Ibid.*, p. 84, 1885.

or saddlery hardware. From the railroad point of view, however, cheaper rates on raw materials might have tended strongly to encourage the growth of manufacture in Denver, and ultimately make for the self-sufficiency of the region. This might mean less freight in the future.

At this time Mr. Light's concern had travelers making the towns in Texas, New Mexico, Arizona, Kansas, Nebraska, Idaho, Montana, and they had gone even as far as Hailey, Oregon. The goods sold over this large territory were certain specialties that were well adapted to the uses of this particular region. The competition which these agents encountered was particularly with the California dealers. Goods could be shipped from the East to the California houses more cheaply than they could be shipped to Denver. The goods thus went through to the Pacific points cheaper than they could be stopped off at Denver. In this way the San Francisco dealer could get into Idaho and other parts of the West and undersell the Denver man. Goods were thus carried across the continent and then shipped back again to the points reached by the San Francisco trade. It was the custom of Mr. Light's firm to sell to certain dealers in various parts of the states above mentioned and have the goods shipped directly from the factory to the dealer as the rate would have greatly raised the price had the goods been shipped via Denver. This was considered bad business by the wholesaler as it was said to bring the manufacturer and the dealer into closer relations and in the course of time the dealer would buy directly from the eastern manufacturer, and the Denver jobber's trade would disappear.

In 1883, Mr. Light had a drummer in Texas who found he could sell a large quantity of wooden stirrups that were made in Ohio. By bringing them in south of the pool lines and getting them to Fort Worth, they could be handled for \$1.10 a hundred. Bringing them to Denver and shipping them thence to Fort Worth would cost \$5.10. Mr. Light presented the case to the freight agent of the Santa Fe explaining that he could handle a large amount of these stirrups and asking if the railroad would not give the same rate on them as was then given on wooden ware, namely \$0.60 a hundred. The agent said he would write to the head office at Topeka and find out about the matter. Before this time Mr. Light's concern had been called the Denver Whip and Collar Company,

but the name had recently been changed to the Denver Manufacturing Company. When this was explained to the agent he said, "The name will kill this thing because you are manufacturers."¹

Mr. Light asked to be allowed to ship in carload lots and then asked if they would make him a special rate on what he shipped south of Emporia which was a pool point. The railroad would then get a haul to Denver and half way back to Kansas City and none of the goods would be sold in the territory of the pooled roads. This proposition was declined on the ground, according to the statement of the freight agent of the company, that Mr. Light was a manufacturer. The reply from Topeka was unfavorable as had been anticipated.

As an indication of the policy of the railroads toward the development of manufactures in the Rocky Mountain region at this time the following incident is worth noting. Mr. Light bought a carload of blankets in Philadelphia in 1884. The freight on these blankets was \$175 from Philadelphia. Of this amount the cost of freight from Philadelphia to Chicago was \$45, and from Chicago to Denver, \$130. For the first half of the journey the freight was one fourth of the total, the second half, from Chicago to Denver, three fourths of the total freight cost.²

The efforts of the Union Pacific to build up Cheyenne and interfere with the progress of Denver which had been the policy of that railroad in the early days lasted till some time previous to 1885 and the rates enjoyed by the merchants in that town were much more favorable than the rates granted to the Denver dealers. Goods shipped to Georgetown and Central City came via Cheyenne. The Union Pacific would not make the same rate to Denver as it was a pool point and Cheyenne was not. If goods were shipped to Denver the Union Pacific would get only one fourth of the freight, but if shipped to Cheyenne, this road would get all. Such a condition prevented the increase of manufacture and trade in Denver. If the Union Pacific hauled to Denver, it would get one fourth of the freight, but if it hauled to Ogden, it would get all the freight. This condition accounts for the lower rates from the Missouri River to Ogden and Salt Lake than to Denver.

Mr. Light formerly manufactured whips in Westfield, Massachusetts.

¹ *Evidence, Special Railroad Committee*, p. 83.

² *Ibid.*, p. 84.

He told the committee that he could make whips more cheaply in Denver. This was because factory workers were cheap in Colorado as so many persons had come out from the East in search of health and while they were not fitted to do the heavy work of the building trades or mines, were nevertheless able to do the lighter work of the factories.¹ He also stated that there was no reason why he should not make whips in Denver and sell them to the entire tributary country save only the adverse railroad rates. He had previously had considerable trade in Trinidad but of late it had greatly fallen off. The merchants there said that they could get the goods more cheaply by shipping them in from the East than they could get them from Denver.

The general conditions in Denver in 1885 were not encouraging to the manufacturing industries. Such industries were at that time declining according to testimony before the special railroad committee. The cause of this decline was said to be the railroad pool. The discriminatory rates against Denver and in favor of Cheyenne, Ogden and Salt Lake, are evidence of the injury to the manufacturing interests of Denver wrought by the pool. It was affirmed before the committee that in the days when there was only the old Kansas Pacific to bring in the goods from the Missouri River, it was possible to have the commodities come in more reasonably than in 1885 when the city had four railroads. It was charged that the classification of freight was almost constantly changed and the rates raised in this way every time the traffic would bear a higher charge. The railroad companies were said to have had an inspector at the freight house whose business it was to open boxes and ascertain if freight was properly classified. If a few first class articles were found in a box of mixed freight the whole box was charged up as first class freight. The railroads regarded it as smuggling.² This was especially the case in the matter of saddlery. If ten dollars worth of harness rosettes were placed in a \$300 box of saddlery hardware, the whole shipment would be put up to first class rates, that being the class to which harness rosettes belonged. In the East harness rosettes were third class freight.³

¹ *Evidence, Special Railroad Committee*, p. 84.

² *Ibid.*, p. 85. Improper freight classification is a serious fraud practiced on railroads. An inspector may have been necessary. See *Report of the United States Industrial Commission*, Vol. IX, p. 288, 1902.

³ *Ibid.*, p. 84, 1885.

These various railway practices were not without their effect on the business of the city. It was stated to the legislative committee that in 1885, 25 per cent. less mechanics were employed than was the case two years before. The number of men in the iron industries was also reduced in the same proportion. Notwithstanding these conditions, many of the business men, especially wholesalers, were at that time friendly to the railroads. The rebating system was then in force and as many of these persons were in the habit of receiving rebates which enabled them to thrive while their competitors were worsted, they naturally remained friendly to the railroad companies. A canner of vegetables agreed to sell to wholesalers as cheaply as they could buy in the East plus the freight. They greatly astonished him by the information that 15 per cent. of the freight should be deducted as this was their rebate. It is said that several of the merchants wanted high rates so they could profit by the rebate they were then getting and at the same time be protected from the competition of new firms that, were it not for this discrimination, might be induced to start business in the city. Rebating was then carried on in other cities of the state besides Denver; Mr. Light told the committee that a merchant in Leadville showed him a check for \$2,000, that being his rebate during a certain period.¹

Freight rates were so adjusted at this time that the Denver merchants and manufacturers could not get into the market at Cheyenne, save only in those cases in which the dealers of the latter city wished their goods sent with great dispatch. In such cases the road would make a rate that would allow the Denver dealer to sell his goods in Cheyenne. Ex-Governor Alva Adams, president of the board of trade at Pueblo, stated in an address that nails made by the Colorado Coal and Iron Company if shipped to El Paso paid a rate of fifty cents a keg. If these nails were bought in the East and shipped to Pueblo, the freight would be twenty-five cents a keg. If they were reshipped at Pueblo and sent to El Paso, the freight to that point would be twenty-five cents more. It thus appears that at that time the manufacturer of nails in Pueblo paid the same rate as the eastern manufacturer whenever he wished to ship to points in what might be called country tributary to his manufactory.²

¹ *Ibid.*, p. 84.

² *Ibid.*

MATCHES

Mr. James D. Davis began the manufacture of matches in Denver in 1883. He started with a capital of four or five thousand dollars and produced from twenty-five to thirty gross a day. When the factory first started, matches could be sold to the merchants at \$2.50 a gross, but he had to sell them very soon at \$1.50 in order to keep his trade, as the rates were reduced on matches brought in from the East. When the factory began operations, the freight rate on matches was \$3.60 a hundred. Very soon after that it was reduced to \$2.60 a hundred, and still later it became the practice to classify matches as wooden ware, and thus classified the rate was one dollar a hundred. When the factory was started, the profit was thirty-five to fifty cents a gross on the manufacture of matches at the Denver factory, but after the profit had declined to five or ten cents in consequence of the reductions in freight rates, it was not profitable to keep the factory running and it accordingly closed down in 1885.¹

One of the prominent merchants of the city of Denver testified before the committee that there was a general break in the rate in the year 1884, and that aside from matches, soap and other commodities were affected. That this rate war was purely a railroad contest is hard to prove. It appears from evidence before the same committee that Kirk and Company were trying to starve out the small manufacturers of soap at this time. It is also true that the Diamond Match Company had a monopoly more or less complete of the match manufacture of the United States. \$27,000,000 worth of matches was manufactured in 1883, and of this amount \$22,000,000 was made by the Diamond Match Company. It is easy to believe that so large a shipper as the Diamond Match Company might have some power in the matter of dictating the rate to be charged by the railroads. After the winter of 1884, the rates on matches and other commodities were again raised. The match factory had then gone out of business.²

SOAP

A soap factory was established in Denver in 1876. In the beginning the factory was somewhat handicapped by the railroads as the freight

¹ *Evidence, Special Railroad Committee*, pp. 22, 23, 133, 139.

² *Ibid.*, p. 133.

rates on the raw material for the manufacture of soap were the same as the rates charged for bringing in soap. The factory was able to make a large product but experienced the greatest difficulty in marketing it as the rates were so made by the railroads as to favor the long haul. At this time there were four roads in the pool and the division on a carload of freight hauled from the River to Colorado points would be more than that resulting from a car of soap shipped from Denver to Las Vegas, or other points in the neighboring territory.¹ After the factory had been running for three or four months and had turned out a soap that would take the market, the freight rate was changed. When the factory was opened, the rate on soap from the Missouri River to Denver was one dollar a hundred pounds and the rate from Chicago to the River was forty cents a hundred. This \$1.40 rate to Denver was lowered as soon as the factory appeared to be successful to 60 cents a hundred pound case.

About 1880 another soap factory was started in Denver. Some time after it had been in operation, the rates on soap from the East were lowered and a great fall in the price occurred. This was the current report in Denver at the time of the investigation by the legislative committee and a number of witnesses testified before the committee. It was the custom to buy the soap that was shipped into Denver with the freight prepaid and this tended to surround the matter with more mystery and lend color to the suspicion that the report was true. At any rate the factory had gone out of business.²

The evidence taken by the committee shows that the freight rate, as in the case of the factory in 1876, was the same on soap and soda, although one car of soda would make many cars of soap. It appeared that there were good opportunities for the manufacture of soap in Denver. It was stated by witnesses before the committee that the price of grease in Denver was lower than it was in the East.

The rate on soap from the Missouri River to Denver was maintained rigidly and honestly from November 1, 1882, to February 28, 1884. On the latter date rate cutting was begun and one cut followed another till the rates were 30 or 40 per cent. of the published freight tariff,

¹ *Ibid.*, pp. 43, 218.

² *Ibid.*, p. 131.

Chicago to Denver. On August 1, 1884, the rates were restored and the plan of the railroad companies was to exact from all shippers the same rate. It was found, however, that Kirk and Company had a contract which ran till the end of the year by which one of the railroads running from Chicago to Council Bluffs agreed to ship their soap below the published tariff. Over this railroad the Union Pacific had no control. After the expiration of this contract Kirk and Company had to pay the same rate as anybody else. It was the practice of Kirk and Company to sell soap in Denver and Salt Lake as cheaply as in Chicago as they wished to break up the manufacture of soap in the West. In this the committee was told Kirk and Company were usually successful. In case the soap makers of the West were not ruined by this competition, they were at least made sufficiently tractable to make a contract according to which the profits were divided and a share given to Kirk and Company. In 1885, there were very few soap factories between the Missouri River and the Pacific Ocean.¹

IRON

Of all manufactures, that of iron is the most important and its development usually takes place first in order of time in all places where such industry attains much magnitude. The attitude therefore of the government or of those in control of the forces affecting the iron industry toward the manufacture of iron is a clear indication as to whether or not it is desired to make that particular section a manufacturing centre. In this respect, the attitude of the railroads is important as showing their desire for manufacturing to develop in any particular place. They constitute certain powerful causes in aid of or injury to manufactures, and it is only necessary to ascertain whether or not they make the freight rate so as to discriminate against the infant manufacturing industry struggling to get started in the newer points reached by the road. The attitude of the railroads therefore toward the growth of the iron manufacture at any point is an indication of their general attitude toward the development of the other manufacturing industries at that place. What was the attitude of the transportation companies toward the iron industry in Denver and Colorado generally in the earlier period?

¹ *Evidence, Special Railroad Committee*, p. 225.

Aside from any interference on the part of the railroads, the natural situation of the state of Colorado and the nature of the industry that was first developed in the state, namely, mining, are conditions that would of necessity have started the iron industry at an early date. Heavy iron machinery was greatly needed in working the mines. Such machinery is expensive to bring in from points 1,000 miles distant as its weight adds greatly to the difficulty in transporting it and freight rates must of necessity be very high. In 1881-82, just after the great mining successes at Leadville, there was a great influx of mining machinery. It was shipped from points beyond the Missouri River, much of it from places as far distant as Pittsburgh, and the average rate of freight was said to have been ten cents a pound.¹ This was an enormous tax on the mining industry of the state. There can be little doubt that this great demand for the products of iron manufacture would have stimulated the development of that industry very rapidly, had it not been for the discriminating freight rates.

The foundry business was started in Denver in 1871. It was handicapped by the rates for the shipment of its products. The freight rates from Denver to points in Arizona, Montana and southern California were the same as from Missouri River points. The foundry shipped in pig iron and coke from the East as these were superior in quality to any made in Colorado at that time. The freight rate on these products was fifteen dollars a ton.²

The freight rates were not favorable to the manufacturer of foundry products then nor did they become so soon. The discrimination in favor of the places on the Missouri River continued. The rates were kept as high on the raw material needed for use in iron manufacture as on the manufactured product. It cost as much in every case except that of pig iron to bring in the raw materials as it did the manufactured machines. This is especially illustrated by the rate on boilers. On 30 per cent. of the material in boilers, the rate was higher than the rate on the manufactured boiler. The rate on the boiler tubes was \$1.15; on the finished boiler, the rate was \$1.00.³ Six firms were engaged in the manufacture of boilers in 1884. The price of boilers was high enough

¹ *Ibid.*, p. 166.

² *Ibid.*, p. 51.

³ *Ibid.*, p. 166.

to encourage their manufacture in Colorado if the railroads would have been willing to change their classification of freight so as not to discriminate against the growth of the manufacture. Most of the boilers made in Colorado at this time were made from scrap iron.¹ If the freight rate on boiler iron had been reduced to 75 cents a hundred, it was said before the committee that the boilers made in Colorado would have been equal to the demand in that state. It was also stated that this lowering of the rate on boiler iron would have had a great effect in developing mining in the state. In 1881-82 when there seemed for a time to be a prospect favoring the growth of this industry, the Colorado Iron Works employed from 150 to 300 men.²

Mr. James W. Nesmith, the president of the Colorado Iron Works, testified before the committee in verification of the testimony already given by other witnesses concerning the discrimination against the development of the iron industry in Colorado. He said it did not pay to manufacture boilers in Colorado as the freight on boilers was at that time less than the freight on the iron from which boilers were made and this iron would have to be shipped in from Pittsburgh. Boilers from the same point could be brought in for less money. To make the boilers in Colorado would have cost as much more as the labor put into the manufacture of them was worth. Mr. Nesmith testified that this discrimination had always existed. There was a rate war beginning June 2, 1884, when for a time there was a difference of twenty-five cents between the freight rates on raw and manufactured iron. The Colorado Iron Works did not manufacture more than 33 per cent. of the boilers which they might manufacture were it not for the discriminating freight tariff. The five or six iron manufacturing concerns in Denver in 1885 had all dropped out of the business of making boilers on account of the unfavorable freight rate, and had devoted themselves to the manufacture of other things. At that time \$1,000,000 was invested in the various machine shops of the city, all of which could engage in the manufacture of boilers were it not for the rate against them. These various shops had a capacity to employ 1,200 men, but owing to the unfavorable attitude of the railroads toward the development of manufactures in the state,

¹ *Evidence, Special Railroad Committee*, p. 169.

² *Ibid.*, p. 168.

these shops were not then and had not been for a year employing more than 150 men. Had there been no rate discrimination, Colorado would have made all the mining machinery needed in the state. However, at that time and with all the shops ready, Denver did not produce more than 25 per cent. of the mining machinery needed in the country tributary to it. It was stated that if there had been at that time the same discrimination between manufactured articles and raw iron as there had been between pig and manufactured iron, the iron manufacture would have developed rapidly in Denver. The rate on pig iron from the Missouri River was fifty cents a hundred; on bar iron \$1.00. If the bar iron was boxed to go into machinery, the rate was sixty cents a hundred.¹ There was a discrimination also against Denver as a distributing point for manufactured articles. The rate from Denver to Wood River was the same as the rate from Omaha and other Missouri River points to Wood River, though the distance was several times as great.²

It was brought out in the testimony before the committee that the Santa Fe charged about 40 per cent. higher rates on freight from Denver to New Mexico points than was charged shippers bringing in their goods from eastern points. As an illustration of this Mr. Davis, a manufacturer of boilers and engines, related to the committee the following incident: He sold a hoisting outfit, boiler and engine, to a person who desired them to be shipped to Los Cerillos, New Mexico. After the bargain had been concluded, other dealers in boilers and engines who were handling goods shipped in from the East offered the purchaser of Mr. Davis' machinery the same goods at a cheaper price. The purchaser stuck to his bargain. Mr. Davis went to see about the freight rate on the outfit to the destination in New Mexico. Before stating the rate, the freight agent asked Mr. Davis where the goods were made. When he was told they were made in Denver, the freight rate announced was considerably higher than the rate from Denver to New Mexico charged commodities that were shipped in and jobbed from Denver. Mr. Davis next tried to ship this outfit through a firm that had a special agreement with the Santa Fe, Jensen, Bliss and Company. "I went to Mr. Bliss and asked him if he would ship it, he said he would and asked what it was; I told him

¹ *Ibid.*, p. 4.

² *Ibid.*

an engine and boiler; he said, 'I can't ship that; it would burst my arrangements up;' he said he had a special contract with them to ship his goods at a special rate but they must be goods shipped in here."¹ This transaction occurred some time previous to January, 1885. Mr. Davis began the preparation of a lawsuit against the Santa Fe on account of this discrimination maintained by it, but found that at that time there was no existing law against it.

Another foundry had started in 1880, but failed as the rates were so high that coal, coke and pig iron could not be brought in to enable the manufacturer to compete with machinery brought in from the East.²

In 1883, the Union Pacific began a fight against the Colorado Coal and Iron Company by lowering the rates on manufactured iron goods. The cut began in Utah and by September 11, had extended to Colorado. This cut affected the company disastrously.³

The same situation confronted other iron industries as was the case with the boiler manufacture. In a new country that was doing so much development work as was being done in Colorado in the decade from 1880 to 1890, much iron to be used in bridges was needed. The roads were being improved in all directions and this meant a great need of bridges. Iron had been found to be the best material of which bridges should be made and it was therefore natural to expect the development in the state of certain bridge manufacturing plants. This did not occur as the rate on bridge iron brought in from the eastern manufactories was so adjusted that the eastern manufacturer could make the bridges and ship them to the Rocky Mountain region more cheaply than they could be made in Colorado. As late as 1884, no iron bridge had ever been made in Colorado. The freight on the raw bridge iron from the Missouri River was \$1.00 per hundred weight, while the freight on the finished bridge was only seventy-five cents. The iron manufacturers stated that twenty-five cents a hundred was a very large profit.⁴ It is thus very clear that as long as this condition prevailed, bridges would continue to be made east of the Missouri River and shipped to Colorado.

¹ *Evidence, Special Railroad Committee*, p. 78.

² *Ibid.*, p. 50.

³ *Ibid.*, p. 218.

⁴ *Ibid.*, p. 168.

POWDER

Some years previous to 1884, a company was formed for the manufacture of powder in Denver. Much of this article was then used in the mining operations in the districts tributary to that city and it occurred to the men promoting the company that the cost of transporting it to Colorado from the East might be saved if its manufacture was begun in Denver. The company secured a patent by which it was claimed that powder could be made for nine cents a pound cheaper than it was then made in the East. The mill was accordingly started. At that time the price of powder was thirty-seven or thirty-eight cents a pound. Immediately after the factory was in operation, the price was put down to twenty cents a pound for powder brought from the East to Denver. It cost more than twenty cents a pound to manufacture powder at the Denver mill. The mill was operated for about six months when the lower prices of powder from the East made it apparent to the stockholders that the enterprise was not likely to be in condition to pay any dividends and the mill was accordingly closed. The stockholders sold out for about 35 cents on the dollar, losing about \$20,000 of the cost of the plant.

It is said that DuPont did not want the mill in Denver to manufacture powder. He wanted the powder to be made in his mills in the East. Mr. Bosworth, who was superintendent of the mill, told the committee that he understood there was a rebate given by the railroad companies as powder was sold in Colorado during the time the mill was in operation for less than it could be made in the East.¹

Just after the Denver factory had started and when the price had been put down, the president of the company, Henry R. Wolcott, went East to investigate the low price of powder. He found that powder making in the East was in the hands of the DuPont monopoly, and that this monopoly in combination with the railroads was too strong for the Denver firm. By lowering the freight rates to Colorado and also the price at which powder was sold in the state, and by recouping itself by higher rates and prices elsewhere, the combine could give away all the powder used in Colorado and still not lose. When this state of affairs was understood, it was felt by the stockholders that it was idle to fight the

¹ *Ibid.*, p. 66.

collusion of the railroads and the trust and although the Denver plant was one of the finest, it was sold out to DuPont at his own figures.¹

Some interesting light is shed on this matter by the testimony of the general freight agent of the Union Pacific Railroad. This agent, Mr. Shelby, stated that his company had had nothing to do with the destruction of the powder-mill. His railroad wanted to go out of the business of transporting high explosives and desired to foster their manufacture in Colorado. To this other roads having terminals in Colorado objected and believed that their interests lay in the transportation of powder to Colorado. The Union Pacific went out of the business of transporting powder for a time and the other roads charged a high tariff for carrying it. Mr. Shelby did not think the rate was lowered for the purpose of destroying the powder factory in Denver. He thought the case was more like the case of the soap factory mentioned above. Kirk wanted to monopolize the manufacture of soap and did so. So with the DuPont powder company; they would give away powder in Colorado rather than let the factory produce it in the state.²

GLASS

The glass industry encountered similar opposition to that which confronted the others already described. It is an industry that tends to establish itself as near as may be to the localities where it is consumed in large quantities as the commodity is one that is liable to loss from breakage resulting from shipment. Thus with the growth of Denver and the cities of Colorado, there was an impetus given to the establishment of glass industries. According to statements by the Denver dealers, during the ten months ending November 1, 1881, \$281,000 worth of glass was sold in Denver. Mr. Burdsall came to the conclusion that this manufacture might be carried on profitably there as all the materials needed in making it were to be found in Colorado and not distant from the city. He intended to utilize the soda lakes near Morrison from which an abundance of soda could be easily brought to Denver. He discussed the matter with the Union Pacific officials and found that the freight on the incoming glass was a considerable item in the income of that railroad,

¹ *Evidence, Special Railroad Committee*, p. 64.

² *Ibid.*, p. 243.

amounting to not less than \$100,000 for the preceding ten months. Mr. Burdsall also discussed with the railroad officials the matter of bringing in soda from Morrison and establishing a glass factory in Denver; they told him that if his company started a factory in Denver, they would put the freight rate on glass from the East down to nothing so as to kill his company's business.¹ They charged Mr. Burdsall \$14 a car to ship some soda, silica, kaolin and so forth from Morrison to Denver. Lime and other products for the Grant Smelter were brought to Denver from the same place for seven dollars a car. The materials near Morrison were so abundant that if the rate from there to Denver could be lowered, glass and sulphate of soda could be made in Denver and sold in the country tributary to that city in defiance of anything the railroads could do. At the prevailing rate east, the product might be shipped to the Missouri River and sold there.²

The general freight agent of the Union Pacific, Mr. Shelby, told the committee that the rates on silica, soda etc. were not fourteen dollars a car if several cars a day were shipped. He said lower rates were not given the Grant Smelter.³ The explanation would seem to be that the Grant Smelter was at that time consuming enough of the material to get a cheaper rate in consequence of larger shipments. Mr. Shelby also stated that at that time the Union Pacific would be glad to encourage a glass factory in Denver and would haul in the materials at as low a rate as four cents a hundred as it was then (1885) doing for the glass factory that had recently started.⁴

Mr. John P. Epley began the manufacture of glass in Denver in 1884. His factory turned out bottles only. These he attempted to sell in the territory tributary to Denver, but had encountered difficulties. He received an order for bottles to be shipped to a point east of Denver on the Burlington, but as soon as the customer ascertained what the freight would be, he canceled the order. The freight rate for bottles made in Denver and shipped to points in the territory adjacent was too high to allow such manufacture to develop. After the factory had been started, the freight rates on bottles from the East were lowered. In consequence,

¹ *Ibid.*, p. 147.

² *Ibid.*, p. 149.

³ *Ibid.*, p. 248.

⁴ *Ibid.*

the price of the bottles made in Denver had to be lowered to meet the competition and hold the customers which the new factory had secured in Denver. None of the materials used in the manufacture of bottles by this factory were brought in from the East. The soda was brought from Wyoming. When this glass company attempted to extend its trade to the southern part of Colorado, territory served by the Santa Fe railroad, it encountered difficulties as the freight rate from Denver to the points in this territory had been raised during the year 1884 and just after the glass factory had started.¹

CARRIAGES

The difficulties which the manufacturer of carriages suffered on account of the arrangement of the freight rates were related to the investigating committee of the legislature by Mr. D.K. Wall, a carriage manufacturer who was employing from fifteen to twenty-five men in his factory in 1885. Mr. Wall stated that the freight rate on carriages partly finished in the white as it is called was the same as the rate on the finished product. Carriages made in Colorado were said by this manufacturer to be superior to those made in the East owing to the greater dryness of the atmosphere and the fact that the timber would in consequence be so much better seasoned. Mr. Wall thought carriage manufacture could be carried on as well in Denver as anywhere as it is the custom for all carriage manufactories to have certain parts used in the manufacture shipped in from points all over the United States. The rate on carriages from the Missouri River at that time was \$1.37½ a hundred weight, the same as the rate on carriage wheels in the white or other parts of the vehicle. He stated that if rates were proportioned according to the value of the article, carriages would be made in Denver at a very good profit. Many laborers had come out to Colorado for their health and unable to do heavy work would be very happy to find work such as is required in a carriage factory and which they would be able to perform successfully.²

Another carriage manufacturer employing from fifteen to twenty-five men confirmed the testimony of Mr. Wall, stating that everything that

¹ *Evidence, Special Railroad Committee*, p. 55.

² *Ibid.*, p. 157.

goes into a carriage is charged at a higher freight rate than the finished carriage when that is shipped from the East. This manufacturer, Mr. Melburn, stated that in 1883 he had asked that the rates on all the things that go to make a wagon, wheels, springs, carriage bolts etc. be so adjusted that they would be the same as the rate on manufactured wagons. This the railroad officials refused and said the articles could be classified only after their arrival here. The rates were such that the freight on a car of finished wagons from the Missouri River to Denver would cost \$200, but the car of parts of wagons from the Missouri River would have to pay freight amounting to \$365. The manufacturer stated that four carriage wheels in raw material ironed cost \$17.40, but when painted and ready for the wagon they were worth \$32, the difference being due to the additional labor put on them. If the freight on this \$17.40 of raw material were in the same proportion to the value of the material as the freight on the manufactured article was to its value, carriages could be made in Denver and the Denver manufacturers would control the trade. Their profits would be increased about 10 per cent., said Mr. Melburn. It seems that at that time the carriages made in Colorado would sell for a little more than those shipped from the East.¹

An interesting light is thrown on the carriage trade by the testimony of this manufacturer. It seems that when he began the manufacture of wagons in 1877, vehicles made in Colorado were not in demand, but by 1884 the preference was given to the wagons that were made in the state. It was estimated at that time that the wagons made in the state would last 20 per cent. longer because of the better seasoning of the timber put into them, due, of course, to the dryness of the climate. A lowering of the rates would enable him to employ in his factory 300 more hands. At that time not more than 125 men were employed in this kind of manufacture in the entire city. The witness stated that the employment of 300 more men would mean a difference in the population of the city of from 1,500 to 2,000.²

BUILDING MATERIAL AND FURNITURE

The freight rates had their effect on the manufacture of the higher grades of building material and furniture. Sash, doors and blinds

¹ *Ibid.*

² *Ibid.*, p. 157.

made in Denver could not be marketed north of the Union Pacific nor south of the Santa Fe. One of the prominent lumber dealers in Denver stated that in 1882 he could make doors and started in the business but the Chicago firms got the rates lowered so that in 1885, doors could not be made in Colorado. In 1885, the rate on glazed sash from the Missouri River to Colorado common points was seventy-five cents; on window glass the freight rate from the River was one dollar. Therefore glazing could not well be done in Denver. At that time only odd sizes of sash and the like were made in the city. These sizes did not compete with the product shipped in from the East and the manufacturer was therefore allowed to sell them north of the Union Pacific railroad. His market could not be extended to the towns within a short distance of Denver such as Longmont, Colorado Springs or Pueblo. The freight rate on such goods from the East to these points was the same as the rate from Denver.¹

Mr. Henry C. Taussig, a manufacturer of packing-boxes, stated that the freight rate on such boxes complete in the knock-down shape from the Missouri River to Colorado points was the same as the rate on the rough lumber of which such boxes were made. There was also considerable waste in the manufacture of these boxes. Mr. Taussig stated that this rate was special to certain dealers in the city. Some makers of crackers and soap were getting their boxes from the East in 1885. The rate had not recently been lowered, but the classification of packing-boxes had been changed. He could not sell to the soap factory in Pueblo as the rate from Kansas City to Pueblo was the same as the rate from Kansas City to Denver. The rate on lumber from the mountains of Colorado about 75 miles distant was \$1.65 a hundred weight, while the rate on lumber from Kansas City, 600 miles, was fifty cents.²

A broom factory was started in Denver in 1880. The market was mostly local owing to the unfavorable freight rates from the East as compared with the rates from the Denver manufactory. Brooms were shipped from various points between the Missouri River and Denver to points in the Mountains at \$40 a car. The rate on brooms shipped from the Denver factory to the same points in the Mountains was \$130 to \$150 a car. Manufactured brooms were also shipped from the Missouri

¹ *Evidence, Special Railroad Committee*, pp. 73, 79, 81.

² *Ibid.*, p. 33.

River to Denver at the same rate as raw material. Brooms were classified as wooden and willow ware, the same as raw material. It cost more at that time to ship a carload of broom handles from the River to Denver than it cost to ship a carload of brooms.¹ Mr. Shelby, freight agent of the Union Pacific, said that these rates would be modified so as to give the Denver broom manufacturer a market from 100 to 200 miles east of the city.²

A furniture dealer who had also been engaged in the manufacture of mattresses stated that he had had to abandon their manufacture on account of the unfavorable freight rate on goods brought in from the East. Rates on materials from which mattresses are made were \$1.05 from the Missouri River to Colorado. After the manufacture had begun in Denver, the rate on these materials was advanced to \$1.45. Then the firm ceased to manufacture and bought the mattresses in the East. Mr. Gartner, the manufacturer, stated that the rates on the raw material for upholstered goods were the same as for the finished article. Mr. Stewart, another manufacturer of mattresses, confirmed what Mr. Gartner had said and added other interesting items. He had begun the manufacture of mattresses in 1881 and soon found that the freight rates were unfavorable to the extension of his market over territory south of Denver. Freight rates to New Mexican points had been raised after the factory started. Formerly the rate on mattresses from Denver to Las Vegas was \$1.55; in 1885, it was \$2.80. The old rate to Albuquerque was \$2.15; in 1885, it was \$3.80. Until 1884 or 1885, the rates from Denver to points in New Mexico were higher than the rates from the Missouri River to these points. This, of course, did not encourage the growth of his market. The freight rate on bed springs was lower than the rate on the raw wire of which these bed springs were made.³

The freight rate on chairs in knock-down condition was the same as the rate on chairs set up and finished if shipped in carload lots. Looking glass plates were charged the same freight rate as finished looking glasses, and all furniture, whether in the raw or finished condition, paid

¹ *Ibid.*, p. 39.

³ *Ibid.*, p. 28.

² *Ibid.*, p. 85.

the same rate.¹ Labor was higher in Colorado and without a considerable difference in the raw and manufactured goods, furniture could not be finished in Denver.²

CEMENT AND TERRA COTTA

Fire brick, cement and terra cotta works in Denver had each similar experiences to those of the other industries already mentioned. The fire brick company could not enlarge its market on account of the unfavorable freight rates. The cost of manufacturing this commodity in Denver was somewhat higher than at the Missouri River points as the coal had to be hauled in and labor was higher. After the article was manufactured, however, the rates from Denver to points in Idaho and Montana were the same as the rate to those points from places on the Missouri River.³ This condition confined the fire brick made in Denver to the local market.

Much the same condition confronted the manufacturers of cement in Denver in the years preceding 1885. The firm could not sell its product in Salt Lake as the rate from Denver to Salt Lake was about the same as the rate from the Missouri River to Salt Lake and hence, the manufacturer at the River who could produce more cheaply had the advantage over the Denver manufacturer. The freight rate from Denver to Albuquerque was the same as the rate from the Missouri River to the same point. This was true generally of the rates to points in Mexico. In 1885, the freight rate on cement from Denver to Cheyenne was lower than the rate from the River to that point but the Denver company could not sell cement in Cheyenne. Mr. Evans, the secretary of the company, stated that he thought the merchants in Cheyenne were getting rebates at that time, and that the public schedule did not obtain. He said his company had nearly closed a contract for three cars in that city, but the Union Pacific learned of it and cut the freight rate so that the company lost the contract and the cement was hauled from the Missouri River. After the factory had been started in Denver, the freight rate on cement from the Missouri River to Denver was greatly lowered, whether to injure the factory or not the secretary said he did not know.⁴

The terra cotta stone works were built in 1881 and the product was

¹ *Evidence, Special Railroad Committee*, p. 91.

² *Ibid.*, p. 142.

³ *Ibid.*, p. 35.

⁴ *Ibid.*, p. 42.

soon more than sufficient to supply the local market. The owner, Mr. Moulton, sought to sell his surplus in Salt Lake. He found to his astonishment that the freight rate on a car of his products from Denver to Salt Lake was \$75 more than the rate on the same products from the Missouri River to Salt Lake. Eastern firms at Akron, Ohio, Peoria, Ill., and Des Moines, Iowa, were then competing in the Denver market. Since Mr. Moulton's factory was started, the freight rate from the Missouri River to Denver had been greatly lowered. He stated that if the rates had remained the same as they were when his factory began operations, he would be able to compete with eastern manufacturers. The rate then existing on terra cotta products from Denver to Salt Lake was \$250 a car. The rate from Omaha to Salt Lake on the same products was \$175 a car. This effectually shut out Denver from the market in Salt Lak . Seventy-five dollars a car was a handsome profit according to the testimony of the Denver manufacturer.¹

GROCERIES

The grocery business was so discriminated against by the freight rate that Denver could not become a distributing point for the Rocky Mountain country. It was stated in the evidence before the railroad committee, that the Kansas Pacific Railroad was capitalized at \$250,000 a mile which sum was vastly beyond the cost of constructing it, and that in consequence of this great capitalization, it was the desire of the railroad company to secure all the returns in freight that could possibly be obtained. The same was more or less true of the capitalization of the other railroads that at that time terminated in Denver or other parts of the state. It was alleged that the railroads expected the people to pay interest on this enormous capitalization, and hence the high rates for everything carried into the state. Mr. Shelby, general freight agent of the Union Pacific, stated that during the preceding year, the Union Pacific fell short of paying expenses and interest on bonds by \$623,299.² It was also charged by Mr. Martin, a wholesale grocer, that the goods shipped to Colorado were frequently overweighed. He had brought a suit against the railroad company on this charge and had won the suit.³

¹ *Ibid.*, p. 171.

² *Ibid.*, p. 240.

³ *Ibid.*, p. 61.

The following table of freight rates on the various groceries shows very clearly the discrimination in that business:¹

CANNED GOODS	
California to Boston.....	\$1.25
California to Cheyenne.....	1.20
California to Atchison.....	1.25
California to Denver.....	1.70
DRIED FRUITS	
California to Chicago.....	1.85
California to Denver.....	2.60
RAISINS	
California to Missouri River.....	1.50
California to Denver.....	2.50
NUTS	
California to Chicago.....	1.80
California to Denver.....	2.50
BEANS	
California to Chicago.....	1.50
California to St. Louis.....	1.50
California to Cincinnati.....	1.50
California to Denver.....	1.70
COFFEE AND RICE	
California to Missouri River.....	1.16
California to Denver.....	1.70
FRUITS AND VEGETABLES (CAR LOTS)	
California to Chicago.....	1.25
California to Denver.....	1.75
California to Denver (less car lots).....	3.50
SUGAR	
California to Kansas City.....	1.00
California to Denver.....	1.40
RICE	
California to Kansas City.....	1.00
California to Denver.....	1.40

By this table it appears that all staple groceries that came from California to Denver were charged at a higher rate of freight than if they

¹ *Evidence, Special Railroad Committee, p. 60.*

went on through to the Missouri River or Chicago. As a general rule, all fifth class goods which consisted of groceries were hauled from California to the Missouri River points for one dollar, but to Denver, six hundred miles shorter haul, the rate was \$1.50. Green fruits shipped from California to Denver paid a rate of two cents a pound, but if shipped through to the Missouri River, New York or Chicago, the rate was one cent a pound.¹ A number of wholesale grocers confirmed this testimony.² Isaac Brinker, a retired grocer, bought syrup in California and shipped it to the Missouri River and then back from the River to Denver in order to get the advantage of the lower freight rate.³ Mr. Wolfe Londoner, one of the wholesalers of Denver, stated that the railroad pool was a great injury to the business interests of the city. The rates were so arranged as to favor shipping in manufactured goods. He had lost his trade at Trinidad, Colorado Springs and Grand Junction, on account of the discrimination against Denver as a distributing point. The freight rate from Chicago to Salt Lake injured the trade of the Denver wholesalers and destroyed the trade with Grand Junction. It was hard for the wholesalers to live at that time as the rates were so unfavorable. Merchants in Georgetown and other points in the interior of the state could get the same rate as the Denver wholesaler and as a consequence, they ceased buying from the Denver house and bought directly from the firms in the East or elsewhere.⁴ It was impossible to ship groceries to Utah from Colorado. California competed with the East. Canned goods, coffee, rice, dried fruit, liquors, cigars, machinery and nails were hauled from California to Utah because these all came to California by water and at a very low rates. They had been shipped from California to points in Utah at as low as thirty-five cents a hundred weight. This is why the freight rate on nails from Pittsburgh to California was sixty-five cents a hundred.⁵

In explaining why fifth class freight was carried from California to Chicago and Omaha more cheaply than to Denver, Mr. Shelby, general freight agent of the Union Pacific, said that there was water

¹ *Ibid.*, p. 243. Mr. Shelby, general freight agent of the Union Pacific, said this was not true in 1885.

² *Ibid.*, pp. 133, 97.

⁴ *Ibid.*, pp. 139, 140.

³ *Ibid.*, p. 111.

⁵ *Ibid.*, p. 199.

competition at these points and there was no water competition at Denver. These articles were shipped around Cape Horn.¹

COAL MINING

It appears also that the business of coal mining upon which the growth of manufacturing industry depends was not greatly encouraged by the railroads. Various witnesses before the committee testified to discriminations of different kinds which interfered with the profitable conduct of the business. Mr. Langford who was at that time operating the Marshall Mine about sixteen miles from Denver stated that the freight rate on coal from the mine to Denver was \$1.25 a ton. The Louisville Mine was operated by the Union Coal Company and was two miles farther from Denver than the Marshall Mine, but the rate on coal from the Louisville Mine to Denver was only twenty-five cents a ton. This was denied by the general freight agent of the Union Pacific who said the Union Coal Company was a department of the Union Pacific Railroad.² The directors and stockholders of the Louisville Mine were the same as the largest stockholders in the Union Pacific Railroad Company.³ Mr. Goodrich who was mining coal at Erie confirmed the testimony of Mr. Langford. He stated that he was obliged to pay \$1.00 a ton to get his coal from Erie to Denver, and that he could not sell in the Mountains nor south of Denver as the freight rate was discriminatory.⁴

The sale of Colorado coal outside of the state was not encouraged by the railroads. A Denver dealer got orders for coal at places in Kansas. The Union Pacific quoted him a rate of \$3.50 a ton for the shipment of coal to these points. A traveler had been sent out and had worked up considerable trade. Three cars were sent over the Union Pacific. Then an order came to receive no more cars, and the shipper had to abandon the attempt to sell in Kansas. Coal was at that time being mined in Gunnison County and shipped to Denver ready for the markets in Kansas and Nebraska. The coal came over the Rio Grande. The Union Pacific raised the freight rate for hauling coal to points in the states east of Colorado to \$10.00 a ton. The officials of the Union

¹ *Evidence, Special Railroad Committee*, p. 248.

² *Ibid.*, p. 239.

³ *Ibid.*, p. 50.

⁴ *Ibid.*, p. 64.

Pacific said they were not receiving any freight from the Rio Grande at that time. A similar case happened with the Santa Fe. As soon as it was learned that the coal came from Colorado, a prohibitory tariff was fixed.¹

It is stated in the report of the railroad commissioner for the year 1885 that the price of coal was exorbitantly high to the consumers in many parts of the state. This was due to the large profits secured by the dealers and not to any extreme cost of production. It appeared that the dealers in many instances had been able to secure a monopoly of the business through connivance with the railroad companies. Discrimination had, therefore, become so common that it became a settled conviction in the public mind that a coal measure in the state was without value unless owned by or in connection with a railroad company, and that the transportation companies controlled the price of the entire product. Whether or not this was true, the report does not say.²

The explanation of the railroads being engaged in the business of coal mining is, however, not without great interest because of the light it throws on the development of manufactures in the state. When the railroads reached Colorado in the summer and fall of 1870, a demand for coal was created. The consumption by the railroads was more than the mines could produce with their equipment at that time. Hence, the era of railroads created a demand for the investment of more capital in the coal mining business. This capital was not furnished by private parties as their wealth was invested in the mining of precious metals. The Colorado immigrant of the earlier decade came for the purpose of mining gold and not coal. His relation to the coal mining industry was that of consumer rather than producer. If the railroads had not engaged at that time in the mining of coal, it is quite possible that their excessive demands on the small amount of private capital invested in the business would have added a scarcity value to the product. It was on this account that the railroad ownership and operation of coal mines was not in the earlier decades considered a serious menace to the welfare of the state.³ The commissioner of railroads stated that as private enterprise entered

¹ *Ibid.*, pp. 104, 105.

² *Report of the Railroad Commissioner*, pp. 63, 65, 1885.

³ *Ibid.*, p. 66, 1885.

the field, the railway manager could not fail to see that the interest of his company would not be advanced by his staying in the markets as a commercial trader and antagonizing the patrons of his road.¹ The difficulty with the situation in 1885 was the monopoly of the business by the railroads and their affiliated dealers so that private capital was discouraged from going into the business. As a result of this situation, the high price of this most essential commodity had a depressing effect on the minds of those persons who were considering the establishment of new manufacturing plants in the state.

¹ *Report of the Railroad Commissioner*, p. 66, 1885.

CHAPTER III. TESTIMONY OF RAILROAD OFFICIALS

The true attitude of the railroads toward the growth of manufacture in Colorado during this period is perhaps most clearly shown by the statements of the freight agents before the investigating committee of 1885. The freight agent of the Santa Fe testified that the rate on freight from Denver to points in New Mexico was uniformly more than the rate from Kansas City. He said it averaged 40 per cent. more on goods made in Colorado. The rate was uniformly more to Denver and from there to destination than was the case if the freight went through direct. The then existing rates were not published in the rate sheet, but were gotten up in a hektograph form and distributed among some of the shippers. The date of the sheet exhibited to the committee was January 1, 1882. It showed a pronounced discrimination against Colorado manufacturers. These rates applied on jobbing business.¹ They were as follows:

DISCRIMINATION AGAINST COLORADO MANUFACTURERS

Furniture made in the East	Pueblo to Albuquerque	\$1.40
" " " Colorado	" " "	2.15
Fourth class goods made in the East	" " "	1.15
" " " " Colorado	" " "	1.47
First class goods made in the East	" " Socorro	1.65
" " " " Colorado	" " "	2.50
Fourth class goods made in the East	" " "	1.35
" " " " Colorado	" " "	1.70
First class goods made in the East	" " Deming	2.15
" " " " Colorado	" " "	3.20
Fourth class goods made in the East	" " "	1.75
" " " " Colorado	" " "	2.12
Iron made in the East	" " Socorro	1.35
" " " Colorado	" " "	1.70
Nails made in the East (car lots)	" " "	1.15
" " " Colorado	" " "	1.60

¹ Evidence, Special Railroad Committee, pp. 106, 107.

The freight rate was usually from 50 per cent. to 75 per cent. more from Denver to points in Arizona and New Mexico than from Kansas City 600 or 700 miles farther distant. Much the same situation prevailed with regard to the freight rates from Omaha.¹ These rates show that the man with the capital to invest in manufacturing enterprises would be driven out of Colorado and would probably locate his factory at some point on the Missouri River.

From the railway point of view some light is shed on the above table of rates by the testimony of Mr. Hamblin, the general freight agent of the Santa Fe. He stated that the rate tariff was made the last of 1882 or early in 1883, and that according to this tariff, the rates were as shown in the table. The aim of the railroad at that time was to increase its revenues. Since January, 1884, Mr. Hamblin said this tariff had not been in use. Formerly, however, this road had discriminated against goods made in Colorado and was not anxious to encourage manufactures there. He verified the statements of Mr. Davis concerning the purchase of the hoisting engine. The freight rate on this machinery was higher if the article was made in Colorado.² In explanation of the desire of the railroad to prevent the growth of manufactures in the state, Mr. Hamblin said the Santa Fe was at that time getting 19 per cent. of the business of the Colorado pool, "and of course, controlling all of that line from Kansas City clear down here, we naturally wanted to make as much money as we possibly could and we made a distinction between manufactured articles and those that we shipped in."³

Mr. Hughes, traffic manager of the Rio Grande, stated that the freight rates were made before there were any manufacturers in the state, and that it was the desire of the railroad companies to bring in manufactured products cheaply enough so that people could live in the Rocky Mountain region. The railroads tried to favor the consumer rather than stimulate manufacturers. He said there was some justice in the complaints that were at that time made by the persons desiring to start manufacturing in Colorado, and that his railroad was

¹ *Evidence, Special Railroad Committee*, p. 107.

² *Ibid.*, p. 254. See *supra*, p. 25.

³ *Ibid.*, pp. 254, 255.

willing to make a difference between the rate on the raw material and the manufactured product. He thought that if coal, coke and iron were abundant in the state the policy of the railroads toward manufactures might be changed. His road was not willing to haul in everything needed in manufacture and thereby allow manufactures to develop in the state by keeping up the price of the finished article.

In 1882, the Colorado Coal and Iron Company began the manufacture of nails. Immediately thereafter, the Union Pacific lowered the rate on nails from the Missouri River. Prior to their manufacture in Colorado, the rate had been \$1.25; it was reduced to one dollar as soon as the Coal and Iron Company began to turn out this product. There was likewise a lowering of the rate on everything the company turned out as soon as they began the process of manufacture. Mr. Shelby of the Union Pacific testified that this lowering of the rates was true. He said there had been some "isolated cases."¹ In the spring of 1884 a large territory was opened up to the Coal and Iron Company on account of a change in the freight rates which allowed the company to compete with the eastern dealers in the country north and west of Denver. The company was able in January, 1885, to ship its products to Georgetown, Central City, Idaho Springs, Erie, Greeley, Boulder and other points which were inaccessible to it ten months previous to the beginning of the year 1885. The iron ore used by the company in this manufacture was a Colorado product which came from the mines at Calumet and Villa Grove.² Mr. Hughes stated that the Union Pacific had formerly had a rate from the Missouri River to Salt Lake that was the same as the rate from Denver to Salt Lake, but when the new pool was formed and the rates restored, the Rio Grande had obtained a concession that the rates from Colorado points to Salt Lake should be something like 70 per cent. of the rates from the Missouri River to Utah. In consequence of this, the Colorado Coal and Iron Company was selling nails all over Utah and doing the entire business there. After this pool went into operation, the rate on nails from the Missouri River to Utah was \$1.50 while from Pueblo, it was ninety cents.³

¹ *Ibid.*, p. 223.

² *Ibid.*, pp. 218, 219.

³ *Ibid.*, pp. 191, 193.

The reasons for the reduction in the freight rate so as to enable the company to sell in the above district and in Utah were due to the activity of the Rio Grande which was friendly to the Coal and Iron Company as stockholders of the railroad were largely interested in the company, owning half of its stock. When the pool was formed, they insisted upon a readjustment of the rates by the Union Pacific so that the company might be able to sell its products in a larger territory.

The origin of the Colorado Coal (Fuel) and Iron Company at least as far as it has become a factor in the manufacturing industry of the country is due to its reliance upon railroad assistance. Had it been deprived of the close relation with the railroad interest, it is very doubtful whether or not it would have been able to grow into the great manufacturing concern it has become.

About 1873, the Rio Grande railroad was built into Pueblo. General Palmer, the builder, got into difficulty when the road had reached this city and found himself short of funds. He wished to build the road from Pueblo to Canon City, a distance of 42 miles. The Colorado Coal and Iron Company had many coal and ore lands in the vicinity of Canon City which they wished to develop. The Coal and Iron Company, therefore, raised the money needed to build the road to Canon City, taking in exchange therefor the stock of the railroad. In this way the road was successfully extended to that point. In a similar fashion, another company bought up the coal and iron lands around Trinidad, Huerfano and some other points, and then turned over one half of their interests to the railroad and on these properties, the funds were raised with which the railroad was built to Trinidad. In 1880 or 1881, in order to develop the resources along the road, General Palmer got the men interested in these properties, both at Trinidad and at Canon City, to put up capital for a steel plant at Pueblo. All the companies were consolidated into the Colorado Coal and Iron Company. About \$2,500,000 was expended at that time. The two contracts which had formerly been made by the railroad by which special favors were granted to the companies in the matter of freight rates were then consolidated into one contract with the combined company. This contract extended spe-

cial favors to the company in the matter of freight rates as the company had united with Palmer in the development of the coal and ore beds and was therefore entitled to a good bargain. This is why, according to the evidence of the receiver of the Rio Grande, no other companies were allowed to sell coal in Leadville except the Colorado Coal and Iron Company.¹ This also explains why the above company shipped coal from Coal Creek to Pueblo at two dollars less a ton than could other shippers at Canon City. The discrimination was even greater than two dollars ordinarily at that point.² This is also sufficient to explain the refusal of the Rio Grande to furnish cars to the other companies even though a number of the cars desired were at that time standing empty on the side track.³

Concerning the railroad attitude toward manufactures in Colorado Mr. Shelby, the general freight agent of the Union Pacific, said:

It would be to the interest of the Union Pacific Company to so adjust their rates between the Missouri River and those Colorado central points, as to make it to the interests of the merchants at these points or at the Missouri River, but when you come to go a step further, you will see that would turn the jobbing merchant of Denver against us, if we were to pursue that policy; so from a business standpoint, we find it to our interest to so adjust our rates as to give the Denver merchant the benefit of dealing with all the merchants in Colorado. There may be some few instances where this plan is not lived up to.⁴

A number of wholesalers had already shown that this plan was not generally lived up to. In theory the rate to the points in central Colorado was the rate to Denver, plus the local rate, but a number of instances are recorded where the dealer in the interior of the state got the same rate as the Denver dealer. As far as the manufacturer was concerned, Mr. Shelby said the Union Pacific was willing to make the freight rate on raw materials 90 per cent. of the rate on manufactured articles in order to encourage manufactures in Colorado.⁵

As to the general question of freight rates from the East to the Rocky Mountains, it is clear that very great pressure was brought to bear on

¹ *Evidence, Special Railroad Committee*, p. 206.

² *Ibid.*, p. 19; *Colorado Daily Tribune*, January 1, 1885.

³ *Evidence, Special Railroad Committee*, p. 67.

⁴ *Ibid.*, p. 240.

⁵ *Ibid.*, p. 228.

the railroads by the manufacturers of the eastern states to induce them to keep the rate favorable for the shipment of eastern articles to that region. It was not a matter of purely selfish interest on the part of the railroads alone; whatever selfish interest in the matter they may have had was greatly reinforced by a similar interest on the part of the eastern manufacturers. This is made vividly apparent by the testimony of Mr. Daniels who was at that time the official charged with the administration of the Colorado pool. Repeatedly during 1884, and even as late as the month of January, 1885, the railroads were requested by manufacturers in the East to lower the rates on manufactured goods shipped to the Rocky Mountain region. The reasons stated in these petitions were that the eastern dealers and manufacturers were losing trade in Colorado on account of the growth of manufactures there. The pool commissioner, Mr. Daniels, said the roads refused to do this as they felt that in the end reasonable protection to the manufacturers of Colorado would increase the profits of those engaged in the transportation business.

On January 4, 1885, a meeting of the general freight classification committee was held in St. Louis. At this meeting a number of concessions were made to Colorado manufacturers. Wagon wood was reduced from class A to class B so as to promote the manufacture of wagons in Colorado. Iron bridge material which had been for some years in class B was advanced to class A. This was protecting the Colorado iron manufacturer. A petition from important shippers was presented to the classification meeting asking for a reduction of the freight rate on soap from the East to Colorado, and stating that soap was being made in that state. The Colorado roads protested against any reduction in this rate and the rate was not changed. A similar petition was presented from the manufacturers of matches asking for a reduction in the carload rate to Colorado and stating that matches were being made in the state, and in consequence, the market for easterners was being destroyed. This request was also opposed by the Colorado railroads and the rate was not changed.¹

It was also shown by Mr. Daniels that the railroads, in August,

¹ *Evidence, Special Railroad Committee*, pp. 265, 266.

1884, had reduced the freight rates on the different classes of freight from the Missouri River to Colorado common points. These reductions had been made on the demands of the business men of the leading cities.

FREIGHT RATE REDUCTIONS FROM MISSOURI RIVER TO COLORADO

1st class	reduced from	\$2.40	to	\$2.10	a cwt.
2d	"	"	"	2.00	" 1.70 "
3d	"	"	"	1.75	" 1.40 "
4th	"	"	"	1.35	" 1.15 "
5th	"	"	"	1.25	" 1.00 "

It was said that these reductions were very nearly and in some cases "quite the rates" asked by the shippers. Mr. Daniels said this was evidence of the attitude of the railroads on the freight rate question.¹

On January 30, 1885, a circular was sent out by the Denver chamber of commerce and board of trade containing a letter which had been addressed to the president of that body three days before by the officials representing the railroads of the state. The circular of the chamber of commerce aimed to call the attention of the world to Colorado as a desirable place for the establishment of manufacturing enterprises. It contains the following:

"Many persons in failing health in the eastern states familiar with manufacturing and desiring to establish their particular industries here so as to secure the benefit of our wonderful climate, have hesitated from fears of railroad opposition. The subjoined letter clearly proves that the railroad companies themselves want this idea eradicated."²

At the meeting of railroad officials at which it was decided to issue this letter to the president of the chamber of commerce, all the railroads in the Colorado pool were represented. The general traffic manager, and general freight agent of the Union Pacific, assistant general manager, and general freight agent of the Burlington and Missouri River, the traffic manager of the Santa Fe, the traffic manager of the Rio Grande, and Mr. Daniels, the commissioner of the Colorado Railway Association, were present. The letter is as follows:

¹ *Ibid.*, p. 267.

Ibid., p. 264.

IMPORTANT TO MANUFACTURERS

COLORADO RAILWAY ASSOCIATION
 UNION PACIFIC RAILWAY
 BURLINGTON AND MISSOURI RIVER RY.
 ATCHISON, TOPEKA AND SANTA FE RY.
 DENVER AND RIO GRANDE RY.
 DENVER, SOUTH PARK AND PACIFIC RY.

OFFICE OF THE COMMISSIONER

Denver, Colo., Jan. 27, 1885

R. W. Woodbury, Esq., President of the Denver Chamber of Commerce and Board of Trade, Denver, Colo.:

DEAR SIR: I am instructed by the managers of the lines, members of the Colorado Railway Association, to say to you that they will be glad to use every means within their power, consistent with a broad commercial policy, to encourage manufactures in Colorado and to foster and build up her home institutions; and to this end they will be pleased at all times to meet through their representatives, committees of your association or others for the purpose of discussing means for the advancement of such interests, believing as they do, that the interests of the people of the state of Colorado and of the railroads, members of this association, are largely identical, and that whatever legitimately advances your interests must advance the interests of these railways. The association invites, through your Chamber of Commerce, the attention of manufacturers of the United States to the natural advantages of the Rocky Mountain country for the establishment of industrial enterprises.¹

‡ In the light^{of} what happened in the years succeeding the issue of this circular, it has been said that it was not issued in good faith. This would probably be hard to prove. It is true it was issued at a time when an investigation^{of} the freight rate question was being conducted by a legislative committee and the fear of adverse legislation might have had some influence on the minds of the railroad managers. However this may be, it is certain that the high promises concerning the establishment of manufactures in Denver and Colorado generally that are apparently embraced in the provisions of the letter were not fulfilled by a favorable adjustment of freight rates.

¹ *Second Annual Report of Chamber of Commerce, 1884-85, p. 21.*

CHAPTER IV. 1885-1896

Notwithstanding the fair promises held out in the letter of the pool commissioner to the president of the Denver chamber of commerce, the disadvantageous freight rates of which the shippers complained were not generally readjusted. The legislative committee worked up considerable public sentiment by their investigation and as a result of it the legislature passed a law providing for the appointment of a railroad commissioner. The law was approved April 6, 1885.¹ The commissioner displayed considerable activity and published a creditable report covering the year 1885. No report was published for the year 1886 as there was no appropriation to pay for it.² No future appropriations were made to pay the salary of the commissioner. It has been said that the railroad lobby defeated the appropriations and finally compelled the repeal of the law in 1893.³ Whatever was the attitude of the railroads in this matter, it does not appear that their rate policy was changed. There is abundant evidence that very little had been done to encourage manufacturers by favorable freight rates during the period from 1885 to 1896.

The following is taken from the address of the president of the Denver chamber of commerce delivered in January, 1886:

Your directory is unwilling to believe that Denver, a city aspiring to become a commercial, manufacturing and distributing centre, advertising itself to the world as such, can acquiesce in and much longer continue a condition which is delaying its natural growth and development of business year by year. It is useless to say that freight charges in and out of Denver, are so because of so and so. The fact remains that Denver, amongst many characteristics, enjoys or seems to prefer the distinction of being the highest charged town in the country.⁴

¹ This act was supposed to give the commissioner sufficient power over rates to prevent discrimination though it did not say he had the power to make rates. It empowered him to have compulsory process to secure the attendance of witnesses, obtain books, papers etc. in the investigation of railroad affairs.

² A small report—21 pages—covering the years 1891-92 was published in 1893.

³ The repealing act was vetoed by the governor, but passed both houses, March 30, 1893, by a two-thirds vote and so became law. It was given effect in these words: "Inasmuch as the public interest requires that this act should take effect at once, an emergency exists requiring this act to take effect immediately; therefore this act shall take effect and be in force from and after its passage."—*Session Laws of Colorado*, 1893, chap. cxxxvi.

⁴ *Report of the Chamber of Commerce, Denver*, p. 7, 1896.

Again in a similar address some years later is the following:

It is not possible that the railroads centering here can much longer ignore the importance of the enormous tonnage, but must see that it is to their interest to give to our manufacturers and jobbers a freight rate that will permit of the distribution of goods to a much greater distance than they now enjoy. In fact each year the dealers have to cut the profits to hold their trade to far distant points. Yet with the discriminations by the railroads in favor of cities located on navigable waters, the tonnage continues to develop, and when they see fit to foster the manufacturers and give to them equal rates with those located to the east, Denver will be the most important city between Chicago and San Francisco.¹

An illustration of the attitude of the railways toward the development of manufactures appears in the testimony of Professor Ripley and Mr. Kindel before the United States Industrial Commission. During the years 1890-92, a number of men had planned to build a pulp- and paper-mill in Denver and use the raw materials of that section to manufacture paper for the newspapers that circulate in the Rocky Mountain region. In this way it was thought the great expense of shipping this commodity a thousand miles might be avoided. Plans were under way when the attention of one of the railroads was called to the matter, and the officials of the railroad informed the promoters that if a paper-mill was built in Denver, and thereby the shipment of paper from Wisconsin interfered with, the railroads would kill the enterprise at any cost to themselves. This they threatened to accomplish by lowering the freight rate on paper from the East. The promoters were greatly discouraged, but as the freight rate was very high, they decided to build the mill. Plenty of timber was available in the near-by mountains. Coal mines were in active operation within twenty miles of Denver. The promoters thought there was every reason to believe the mill would succeed owing to the great expense of hauling paper 1,000 miles from Wisconsin. The rate on incoming paper had been \$1.55 a hundred, and the complaints about the high rate had been one of the leading causes that had led to the erection of the mill. As soon as the mill went into operation, the railroads reduced the rate on incoming paper to \$0.25 a hundred. The profits of the enterprise were greatly cut down and the mill finally closed.²

¹ *Report of the Chamber of Commerce, Denver*, p. 57, 1895.

² *Report of the Industrial Commission*, Vol. IV, p. 264, 1902; *ibid.*, Vol. IX, p. 287.

Whether or not the closing of the mill was due entirely to the low rate on incoming paper is not important in this connection. The incident is important as showing the disposition of the great traction interests toward the development of an industry which was likely to reduce their profits from freight haulage.

Under the schedule of freight rates in force in 1894, Chicago and St. Louis manufacturers could ship mining machinery and supplies to points in New Mexico and Arizona "a great deal cheaper" than the same class of goods could be laid down from Denver. It was said that as a matter of fact this was the case with all kinds of manufactured articles. The freight tariff at that time was prohibitory and closed Mexico to Colorado manufacturers and jobbers. As a general rule the rates were the same from Omaha to Denver and to Salt Lake although the latter point was 800 miles farther west. The result of all this was that the Colorado shipper was at the mercy of the eastern manufacturer. Chicago was closer to New and Old Mexico than was Denver. This is one of the ways in which the railroad annihilates space. Manufacturers of mining machinery in Denver stated that were that city placed on an equal footing with the other centres, they could increase their trade threefold within a year. Even as it was, the enterprise of the local manufacturer had in some degree overcome the hardship imposed by the railroad discrimination.¹

On August 17, 1896, the Citizens' League of Arapahoe County adopted a resolution declaring that railroad discrimination had retarded the development of the resources, crippled manufactures and diminished the commerce of the state to a point below the volume it had attained in 1884. The resolution also demanded that a promise be exacted from all candidates for the legislature that they would use their best efforts to enact laws for the establishment of an efficient state railroad commission with power to prevent unjust discriminations and charges.² Perhaps some allowance should be made for other causes which had reduced the commerce of Colorado at the time this resolution was adopted. The closing of the silver mines between 1893 and 1896 was an important

¹ *Denver Republican*, January 1, 1895.

² *Ibid.*, August 18, 1896.

factor in bringing on the depression which prevailed during the latter year. However, the resolution shows that the freight rate discrimination was felt to be a serious grievance.

On May 21, 1896, the Denver chamber of commerce adopted a resolution stating that Colorado industries were subject to extortionate and discriminative transportation rates, and that these rates had reduced the volume of business in many lines below that of 1884. The resolution also provided for the appointment of a committee of three to solicit money to carry on the fight for fair freight rates.¹

It is thus apparent that in 1896 the freight rates were complained of by the most prominent business organizations and the newspapers. Whether or not there was justice in these complaints of the shippers can be determined by an examination of the rates themselves. The following table gives the commodity rates in force in 1896, Chicago to California and to Colorado. A glance is sufficient to show that everything was charged more if it stopped in Colorado than if it went on through to the Coast.

TRANSCONTINENTAL COMMODITY RATES, 1896*

	Chicago to California Terminals. Average Distance 2,500 Miles	Chicago to Colorado Common Points. Average Distance 1,000 Miles
Boots and shoes.....	\$1.50	\$2.05
Burial cases.....	1.50	3.07½
Carpets.....	1.75	2.05
Carpet linings.....	1.50	2.05
Cash registers.....	2.40	4.10
Clothing.....	1.50	2.05
Coffee (roasted and ground).....	.80	1.25
Chocolate L. C. L.....	1.50	2.05
Dry goods.....	1.00	2.05
Drugs and medicines.....	1.20	2.05
Earthenware (plumbers').....	1.00	1.65
Glass (plate).....	1.50	6.15
Glass (colored, decorated etc.).....	1.50	6.15
Hair (compressed, etc.).....	1.00	2.05
Hardware.....	1.00	1.65
Hose (garden).....	1.00	2.05
Iron and steel (bar, road, hoop etc.).....	.50	.77
Iron and steel (boiler and plate).....	.60	.77
Iron pipe.....	.50	.77

* KINDEL, *A B C of Freight Rates*, Denver, p. 17, 1896.

1 KINDEL, *ibid.*, p. 9.

TRANSCONTINENTAL COMMODITY RATES, 1896—Continued

	Chicago to California Terminals. Average Distance 2,500 Miles	Chicago to Colorado Common Points. Aver- age Distance 1,000 Miles
Iron (roofing and corrugated).....	\$.70	\$.77
Iron horseshoes.....	.50	.57
Iron bale ties.....	.50	.57
Japanned ware.....	1.00	2.05
Mats (rubber).....	1.00	2.05
Miners' leather-lined clothing.....	1.50	2.05
Money-drawers.....	1.50	2.05
Mustard.....	1.00	1.65
Mackintoshes.....	1.50	2.05
Nails and spikes.....	.50	.57
Nuts (edible).....	1.00	1.15
Oilcloth (floor) and linoleum.....	1.00	2.05
Paint.....	1.00	1.65
Paper hangings.....	1.00	2.05
Rubber clothing.....	1.00	2.05
Rattan and willow furniture.....	3.40	6.15
Spices.....	1.10	2.05
Screens (foundry).....	1.10	2.05
Sewing machines.....	1.20	2.05
Shoe findings.....	1.50	2.05
Slates (school).....	1.00	2.05
Starch.....	1.00	1.25
Stair pads.....	1.00	2.05
Sweaters.....	1.50	2.05
Shirts.....	1.50	2.05
Stoves (gas, oil etc.).....	1.50	2.05
Tin (pig or bar).....	1.00	1.65
Tiling (art, decorated or inlaid).....	1.10	2.05
Tapioca.....	1.00	1.65
Tobacco (smoking or cut plug, baled).....	1.50	2.05
Tobacco in barrels, boxes or kegs.....	1.40	1.65
Toys.....	1.00	2.05
Type.....	1.00	1.65
Varnish.....	1.00	2.05
Wax (for sealing canned goods).....	1.00	2.05
Window shades.....	1.00	2.05
Water closets.....	1.00	2.05

The following table shows the commodity rates from the California terminal points to Colorado and also to the Missouri River. The same characteristic feature appears as in the other table. It cost more to ship to Colorado than to points on the Missouri River.

TRANSCONTINENTAL COMMODITY RATES, 1896*

	California Terminals to Kansas City, St. Joseph and Omaha, 2,157 Miles	California Terminals to Pueblo, Colorado Springs and Denver, 1,545 Miles
Agricultural implements.....	\$1.35	\$1.40
Brushes.....	1.20	2.20
Blankets.....	1.50	2.50
Chocolate.....	1.00	2.20
Sugar.....	.50	.75
Drugs and medicines.....	1.20	3.00
Hides (green).....	1.00	1.30
Honey.....	.75	1.10
Ink.....	1.00	3.00
Lard and substitutes.....	1.10	1.30
Machinery, class A.....	1.10	1.40
Oilcloth (floor) and linoleum.....	.75	1.90
Paint (earth and mineral).....	.75	1.00
Rice.....	.50	1.00
Soap.....	.75	.82
Skins, Russian sable, silver fox, sea otter and blue fox.....	3.50	6.00
Martin, fisher, cross fox and white fox.....	3.00	6.00
Bear, beaver, otter, mink, lynx and red fox .	2.80	6.00
Deer, raccoon, muskrat, squirrel, reindeer etc .	2.50	3.00

* KINDEL, *op. cit.*, p. 24.

Colorado was under similar disadvantages when it came to shipping goods out of the state. It did not seem to be the scheme of the man who made the rates to allow Denver to be a distributing point. The following tables giving the freight rates from Colorado cities to certain points, and also the rates from other cities to these same points, show that it generally cost more to ship from Colorado than from other cities even though in the latter case the haul was often much longer.

FIRST CLASS RATES, 1895*

New York to San Francisco.....	\$1.00
Chicago to San Francisco.....	1.00
New Orleans to San Francisco.....	1.00
Omaha to San Francisco.....	1.00
Denver to San Francisco.....	3.00
Omaha to Salt Lake.....	1.65
Denver to Salt Lake.....	1.65
Chicago to El Paso.....	1.62
Denver to El Paso.....	2.00

* KINDEL, *op. cit.*, p. 53.

FIRST CLASS RATES, 1895—Continued

Omaha to Julesburg.....	\$1.00
Denver to Julesburg.....	.87
Kansas City to Haighler, Neb.....	.89
Omaha to Haighler, Neb.....	.84
Denver to Haighler, Neb.....	.87
Missouri River to Chappell, Neb.....	1.01
Denver to Chappell, Neb.....	1.25
Missouri River to Rock Springs, Wyo...	1.65
Denver to Rock Springs, Wyo.....	1.65

A slight advantage in rates was given to Denver over Missouri River points in shipments to other places in Wyoming.¹

DISCRIMINATION IN FAVOR OF MISSOURI RIVER POINTS, 1896*

Commodity Rates	Omaha, Kansas City and St. Joseph to California Terminals	Denver, Colorado Springs and Pueblo to California Terminals
Acid.....	\$0.90	\$1.40
Agricultural implements.....	1.05	1.40
Babbit metal.....	.75	1.75
Blue vitrol.....	.75	1.60
Boots and shoes.....	1.50	3.00
Bottles (glass).....	.65	1.60
Boxes (paper).....	1.00	6.00
Brass goods.....	1.00	2.60
Brooms.....	1.95	3.00
Brushes (shoe, scrub, stove).....	1.20	3.00
Cans (tin).....	.75	1.60
Cars (street).....	1.35	1.40
Car seats and backs.....	1.45	3.00
Cheese.....	1.65	2.60
Chimneys and lantern globes (glass).....	.90	2.00
China.....	1.00	3.00
Clothing, overalls.....	1.50	3.00
Coffee (roasted, ground).....	.80	2.00
Copper goods.....	1.00	2.60
Crockery and queensware.....	.85	1.60
Drugs and medicines.....	1.20	3.00
Dry goods.....	1.50	3.00
Filters (stone).....	1.00	1.75
Flasks (glass).....	.65	1.60
Fuel (composition).....	1.00	2.00
Fuse.....	1.20	3.00
Glass (window).....	.65	1.60

* KINDEL, *op. cit.*, p. 23.

¹ *Ibid.*, p. 16.

DISCRIMINATION IN FAVOR OF MISSOURI RIVER POINTS, 1896—*Continued*

Commodity Rates	Omaha, Kansas City and St. Joseph to California Terminals	Denver, Colorado Springs and Pueblo to California Terminals
Glassware.....	\$.85	\$2.00
Grates (iron).....	1.00	1.40
Hosiery.....	1.20	3.00
Hardware.....	1.00	3.00
Ink.....	1.00	3.00
Jars and glasses (glass).....	.65	1.60
Lamps (glass).....	1.00	3.00
Lead pipe.....	.75	1.60
Machinery (class A).....	1.10	1.40
Matches.....	1.00	1.75
Mining car wheels.....	1.00	1.75
Pickles.....	.90	1.60
Pipe (sewer clay).....	.65	.80
Solder.....	1.00	2.00
Soap.....	.75	.82
Tinware.....	.75	1.75

PECULIARITIES OF FREIGHT RATE DISCRIMINATION, 1896*

	Rate
<i>Beer—</i>	
Denver to Leadville, 151 miles.....	\$0.60
St. Louis to Leadville, 1,000 miles.....	.70
Denver to La Junta, 180 miles.....	.37
Kansas City to La Junta, 571 miles.....	.30
<i>Plate glass: commodity rate—</i>	
Chicago to Denver.....	1.25
Chicago to San Francisco.....	1.10
<i>Single large plates—</i>	
Chicago to Denver.....	6.15
Chicago to San Francisco.....	1.50
<i>Chocolate—</i>	
Boston to Denver, water and rail.....	2.29
Boston to Denver, all rail.....	2.60
Boston to San Francisco.....	1.00
<i>Machinery: class A—</i>	
Chicago to Denver.....	1.40
Chicago to San Francisco.....	1.10

* KINDEL, *op. cit.*, pp. 24, 37.

Oil—

Chicago to San Francisco.....	.78½
Colorado common points to San Francisco	.96

Pickles—

Chicago to San Francisco.....	.90
Denver to San Francisco.....	1.60

Soap—

Chicago to San Francisco.....	.75
Chicago to Denver.....	.77
Denver to San Francisco.....	.82

FREIGHT RATES, DENVER TO SAN FRANCISCO, 1896*

	1st Class	2d Class	3d Class	4th Class	5th Class
Chicago to San Francisco.....	\$2.40	\$2.15	\$2.00	\$1.70	\$1.65
Denver to San Francisco.....	3.00	2.60	2.00	1.75	1.60
San Francisco to Denver.....	3.00	2.60	1.90	1.55	1.30

* KINDEL, *op. cit.*, p. 36.

The following table of rates shows the impracticability of carrying on the jobbing business in Denver under the discriminations prevailing in 1896. Shale is a town on the Rio Grande Railway 28 miles west of Grand Junction.

Chicago to Omaha.....	\$0.80
Omaha to Shale.....	1.65
	<u>\$2.45</u>
Chicago to Denver.....	\$2.05
Denver to Grand Junction.....	1.75
Grand Junction to Shale.....	.35
	<u>\$4.15</u>
Denver jobber's rate in excess of Omaha's.....	\$1.70

By 1895 the jobbing business in Colorado had not reached any appreciable development, most of the jobbers supplying the state having found it more profitable to locate at the Missouri River.¹

The rate on cash registers illustrates likewise the same disadvantages of the jobber at that time.²

¹ *Ibid.*, p. 14.

² *Ibid.*, p. 37.

CASH REGISTERS

Chicago or Kansas City to San Francisco.....	\$2.40
Chicago to Denver.....	4.10
Denver to San Francisco.....	6.00
Denver to Grand Junction.....	3.50
Denver to Salt Lake.....	3.30

Some time previous to August, 1896, Messrs. Grove & Pryor, jobbers of hats and gloves in Denver, shipped 600 pounds of gloves from San Francisco. On receipt of them, they discovered that some mistake had been made in filling their order and immediately returned the gloves. They were much surprised to find the rate on gloves was, San Francisco to Denver, 600 pounds at \$2.00 a cwt., \$12.00; return, Denver to San Francisco, 600 pounds at \$3.00 a cwt., \$18.00.¹

In a number of instances, there was in 1896 a discrimination against manufactures in Colorado by a higher freight rate on raw material than on the manufactured goods. This is quite apparent from the rate on material used in the manufacture of mattresses.

In 1883, the railroads first took notice of the manufacture of excelsior in Colorado. At that time the rate from the Missiour River to Denver was \$1.40 a cwt. After the manufacture of excelsior was well begun, the freight rate was reduced to fifty cents a cwt., the same as the rate on cord wood.² The unfavorable freight rate which began in 1883 was still in force in 1895. Manufactured mattresses were charged more than the raw material as appears from the following table:

100 pounds of curled hair in sacks, Chicago to Denver.....	\$4.10
15 pounds of ticking, Chicago to Denver.....	.25
	<hr/>
	\$4.35
115 pounds of mattresses in a car of furniture, Chicago to Denver	1.26
	<hr/>
Raw material in excess of manufactured goods.....	\$3.09

Mattresses are worth at least 10 per cent. more than the raw material on account of the added labor. A grease spot will injure a manufac-

¹ KINDEL, *op. cit.*, p. 37.

² *Ibid.*, p. 54.

tured mattress, but hair in sacks is not likely to be injured very much in transportation. The effect of these rates on the mattress industry in Denver is shown by the fact that when the Brown Palace Hotel was built in that city, the hotel company bought 20,000 pounds of curled hair mattresses, and at that time the freight rate was so adjusted that had the company bought the raw material and had it shipped in and manufactured in Denver, the difference in the freight rate alone was so great that it would have added \$800 to the cost which the company had to pay for the mattresses already manufactured in the East and delivered.¹

The same disadvantage appeared at that time when Denver was considered as a distributing point. The Missouri River cities were favored by the rates.²

100 pounds of moss, New Orleans to Omaha.....	\$0.59	
15 pounds of ticking, Chicago to Omaha.....	.07½	
		0.66½
115 pounds of mattresses, Omaha to Trinidad.....		1.43
Total.....		\$2.09
100 pounds of moss, New Orleans to Denver.....	\$1.59	
15 pounds of ticking, Chicago to Denver.....	.26	
		\$1.85
115 pounds of mattresses, Denver to Trinidad.....	.82	
Total.....		\$2.67
Difference in favor of Omaha.....		\$0.58

A study of freight rates from Denver to the various cities which served as the distributing centres of the country shows that these rates were considerably reduced on January 1, 1895, and remained so reduced till November 1, 1895. At the latter date they were raised somewhat though not to the level of the old schedule. The changes are shown in the following table:

¹ *Ibid.*, p. 45.

² *Ibid.*

RATES FROM DENVER AND COLORADO COMMON POINTS, 1896;* REDUCED JANUARY 1,
1895, AND ADVANCED NOVEMBER 1, 1895

Class	1	2	3	4	5	A	B	C	D	E
To										
<i>Chicago—</i>										
Old rate...	\$2.32	\$1.90	\$1.52	\$1.20	\$1.00	\$1.15	\$0.90	\$0.75	\$0.62½	\$0.56
Reduced ...	2.00	1.55	1.22	.95	.75	.85	.70	.60	.52½	.46
New rate...	2.05	1.65	1.25	.97	.77	.92	.72	.62	.53½	.46
<i>Peoria—</i>										
Old rate...	2.22	1.80	1.47	1.14½	.97½	1.11½	.86	.72½	.60	.53½
Reduced ...	1.90	1.45	1.17	.92½	.72½	.81¼	.66	.57½	.50	.43½
New rate...	1.95	1.55	1.20	.94½	.74½	.88¼	.68	.59½	.51	.43
<i>Mississippi River—</i>										
Old rate...	2.12	1.70	1.42	1.15	.95	1.07½	.82½	.70	.57½	.51
Reduced ...	1.80	1.35	1.12	.90	.70	.77½	.62½	.55	.47½	.41
New rate...	1.85	1.45	1.15	.92	.72	.84½	.64½	.57	.48½	.41
<i>St. Paul—</i>										
Old rate...	2.15	1.75	1.42	1.15	.93	1.07	.83	.70	.59	.52
Reduced ...	1.80	1.40	1.12	.90	.68	.77	.63	.55	.49	.42
New rate...	1.85	1.50	1.15	.92	.70	.84	.65	.57	.50	.42
<i>Missouri River—</i>										
Old rate...	1.60	1.30	1.10	.90	.75	.85	.65	.55	.45	.40
Reduced ...	1.25	.95	.80	.65	.50	.55	.45	.40	.35	.30
New rate...	1.25	1.00	.80	.65	.50	.60	.45	.40	.35	.30
<i>Spokane, etc.—</i>										
Old rate...	2.80	2.40	2.00	1.60	1.40	1.40	1.24	1.00	.88	.72
Reduced ...	1.496	1.32	1.20	1.16	1.04	1.04	.712	.648	.624	.56
New rate...	2.40	2.08	1.76	1.52	1.20	1.16	1.00	.88	.76	.68
<i>Helena—</i>										
Old rate...	2.00	1.72	1.40	1.16	1.00	.88	.736	.656	.576	.49
Reduced ...	1.33	1.20	1.13	1.04	.96	.88	.67	.59	.56	.48
New rate...	2.00	1.72	1.40	1.20	1.00	.92	.80	.72	.60	.52
<i>Galveston—</i>										
Old rate...	2.07	1.73	1.37	1.07	.88	1.04	.80	.65	.52½	.46
Reduced ...	1.75	1.38	1.07	.82	.63	.74	.60	.50	.42½	.36
New rate...	1.30	1.13	.97	.90	.70	.74	.65	.54	.43	.36
<i>Galveston to Denver ..</i>										
	1.80	1.48	1.10	.84	.65	.80	.62	.52	.43½	.36

* KINDEL, *op. cit.*, p. 37.

The reasons for these changes are hard to understand. It may be that the railroads were experimenting to ascertain what the traffic would bear. Some have interpreted the readjustment of rates as a fresh attack on the manufacturing industries then starting in Denver.

For some time before 1896 the rates discriminated heavily against

the manufacture of iron in Pueblo as is shown by the following table. They were lowered, however, in April, 1896.¹

	April 15, 1895, Chicago to San Francisco	Same Date Pueblo to San Francisco	Reduced April 28, 1896, Pueblo to San Francisco
Rails (iron and steel)	\$0.60	\$1.60	\$0.45
Iron (bar) . . . . .	.60	1.60	.37½
Iron billets and blooms . . . . .	.50	1.60	.37½
Iron (pig) . . . . .	.50	.85	.37½
Iron rivets . . . . .	.50	1.60	.37½
Iron nails . . . . .	.50	1.60	.37½
Iron pipe (cast iron) . . . . .	.50	1.20	.37½

This reduction in rates was the result of a decision and order of the United States Inter-State Commerce Commission made in November, 1895, and providing that the rates from Pueblo to California should not exceed 75 per cent. of the rates from Chicago to California. This order the railroads refused to obey. Court proceedings were begun by the commission to enforce the order. Then the railroads obeyed and the rates were lowered as shown above. But this situation was not to last. They kept the rates down about two years, till October 17, 1898. Then the Southern Pacific increased the rates. The Colorado Fuel and Iron Company, on whose complaint the investigation and order was made, sued for damages and an injunction, October, 1898. The Circuit Court enjoined the railroads from charging more than the rates fixed by the commission. But April 16, 1900, the Circuit Court of Appeals reversed the decision on the ground that the United States Supreme Court had ruled that the commission cannot fix rates.²

Notwithstanding a vigorous campaign by Denver shippers and manufacturers to secure Missouri River commodity rates for Denver, they were denied and the following excuse was given by Mr. W. A. Poteet, secretary of the Southern Pacific Company, in a letter dated July 21, 1896. The statement is as follows:

That it was not considered that the circumstances would justify the application of the transcontinental basis of rates to Denver and common points without making

¹ *Ibid.*, p. 12.

² *Inter-State Commerce Commission Reports*, pp. 41-43, 1895; pp. 55-61, 1900; 101 Fed. 779. The appeal to the Supreme Court was dismissed by stipulation, November 1901 (46 L. Ed. 1264); PARSONS, *Heart of the Railroad Problem*, p. 92.

the same basis applicable in surrounding territory and such action would be more apt to have an injurious effect upon the industries of Denver and other centers of trade in Colorado than would the continuance of the present rates.¹

Since 1896 there has been much improvement in the attitude of the transportation companies toward the development of Denver as a manufacturing and distributing centre, but as yet the freight rates are far from satisfactory and the evil effect of the old rates on the city's growth has not been obliterated.

¹ KINDEL, *op. cit.*, p. 35.

FOREIGN DRAMA ON THE ENGLISH AND AMERICAN STAGE¹

II. GERMAN DRAMA

BY CHARLES C. AYER

If Germany has been less prolific than France in furnishing the English and American stage with plays, a study of some good history of German literature and especially an examination of old files of theater programs will show that we are nevertheless indebted to Germany for many valuable contributions to our repertory either in the form of direct translations or as adaptations.

The theater in Germany originated, as it did in France and elsewhere, in the church. It formed a part of the service dealing with sacred subjects or events drawn from the Scriptures or from the lives of the saints. To these were added allegorical representations of didactic trend. From the church the drama gradually moved out upon the public square but did not lose its moralizing tendency even in the plays of Hans Sachs.

With all of this mediaeval theater, we have nothing to do. It merely belongs to dramatic history, as it does in France. Indeed, to find the first German milestone on the English stage, we should move on to modern times without delay, had it not been for Richard Wagner (1813-83). He was inspired to devote his genius to the redevelopment of mediaeval sagas, with the result that, indirectly at least, many of the stories of the Middle Ages are now accessible to us in operatic form. *Tannhäuser* (1845) has been traced back in popular legend to the fourteenth century and *Lohengrin* (1847) to the end of the thirteenth century. Likewise *Parsifal*, the sacred music drama which Wagner dedicated to the festival theater at Bayreuth in 1882, dates back to the famous poem by Wolfram von Eschenbach, which is said to have been written between 1205 and 1220. Also the four operas of the *Nibelungenring*, *Rheingold* (1854), *Die Walküre* (1856), *Siegfried* (1869) and *Die Götterdämmerung* (1874), with which the Bayreuth Festival Theater was opened in 1876,

¹ See "Foreign Drama on the English and American Stage. I. French Drama," *University of Colorado Studies*, Vol. VI, No. 4, pp. 287-97, June, 1909.

were based upon the *Nibelungen Lied*, which dates back as far as the year 1200. Wagner's only comic opera, *Die Meistersinger von Nürnberg* (1868), deals with a love story of the time of the Reformation, with Hans Sachs as one of the leading figures. As Wagner wrote the librettos to all his operas, and as they are now generally regarded in Germany as poetic dramas of high literary excellence, quite apart from the unique music with which he provided them, Wagner may be included here among Germany's leading dramatists.

The history of the Wagner music dramas on the American stage dates from the seventies, when *Lohengrin* (1847) and *The Flying Dutchman* (1841) were given in German. The great enthusiasm, however, did not set in until the eighties when these operas were given admirable performances in English by the ill-fated American Opera Company organized by Mrs. Jeannette L. Thurber, and conducted by Theodore Thomas. Even then and for a long time after, the Wagnerites preferred to hear the operas sung in German, as was done for several seasons at the Metropolitan Opera House. Finally, however, Mr. Henry W. Savage, who had previously devoted his energies to the production of light and comic opera, decided to place the works of Wagner in English in the best possible style on the American stage, with the result that within the past ten years, three of his operas *Tannhäuser*, *Lohengrin* and *The Valkyrie*, have been given in all parts of the United States. It will not be long before the entire number of Wagner's works will be known in English, if one may judge by the great success recently attained by the complete *Ring* given in London last season by an English-speaking company.

As has been said, the German poetic lore of the Middle Ages would not, on its own merits, have claimed the attention of the modern world, had it not been for Wagner. And indeed, it is a long time, many hundred years in fact, before we in any way find a trace of German drama on our modern stage. To be sure, the German theater was cultivated continuously, and plays were written and acted, but their career was ephemeral. After the Middle Ages, the German drama developed through the Reformation period in much the same way as it did elsewhere. The eighteenth century brought the pseudo-classic tragedy

imitated from the pseudo-classic French school of Corneille and Racine. Then came the fine critical and creative work of Lessing in the classic period of the German drama, followed by the melodramatic sensations of the Storm and Stress period. Then followed the romantic works of Goethe and Schiller and the plays of the nineteenth century by writers several of whom are still living and, by the character of their present work, maintaining the drama of Germany upon a high plane.

If, as in the case of the development of the French drama on the English stage, we proceed chronologically, the first date at which we stop is 1787, the year of the production of Schiller's *Don Carlos*. Even this play has no significance for us as a popular favorite known to the average theater-goer. It is interesting to us as having been the second last great production of the late Richard Mansfield. It was not a success, as success is measured by the superficial theater-going public of the present day, but for lovers of the drama, for students and for all those who still cherish ideals of the drama, it was a memorable production. In producing *Don Carlos*, as well as Molière's *Misanthrope* and Ibsen's *Peer Gynt*, Mr. Mansfield was moved by the sincere love of his art, rather than by sordid box-office considerations.

The next date at which we pause is 1796, when Goethe finished his *Wilhelm Meister*. One of the episodes from this long work furnished the ground work for Thomas' opera, *Mignon*, first produced in Paris in 1866 and ever since a favorite in all languages.

The year 1800 marks the first production of Schiller's *Mary Stuart*. This glowing tragedy with its famous scene between Queen Elizabeth and Mary Queen of Scots has long been included in the repertory of the foremost tragic actresses. It is the only play of Schiller which has been a money-maker in America. Strange to say, the most illustrious actresses to appear in *Mary Stuart* on the American stage have been foreigners, Madame Janauschek, a Bohemian, and Madame Modjeska a Pole, both of whom played in English, and Adelaide Ristori who played in Italian.

Schiller's *Maid of Orleans* (1801), which is a favorite in Germany though scarcely known in this country, has nevertheless been brought into prominence recently by the out-of-door performances of the play

as translated and adapted by George Sylvester Viereck and given by Miss Maude Adams, in the Harvard University Stadium in June, 1909.

In 1831, Goethe sealed up complete his *Faust*, on which he had worked for a lifetime. He began his labors as a young man, and finished his work the year before his death at the age of eighty-three. *Faust* is a name not unknown among the veriest Philistines, but the *Faust* which we know from long acquaintance on the American stage, is far from being the *Faust* of Goethe, that treasure-house of philosophy and life experience. What we know as *Faust* is in reality only that portion which in Goethe's *Faust* is known as the Gretchen tragedy, and which served as the basis of Gounod's opera, the melodies of which are familiar to music lovers from St. Petersburg to Valparaiso. It is a fact that among the lesser educated people the world over *Faust* stands for the Gounod opera, which dates only from 1859, rather than for the great work which inspired Gounod.

Faust as a drama was first made known to the American public in the season of 1885-86 when Henry Irving and Ellen Terry with their company and scenery direct from the Lyceum Theater, London, made it the feature of their American tour. The play, however, was not the *Faust* of Goethe, excepting in inspiration. It was the Gretchen tragedy adapted from Goethe's *Faust* and enhanced by the theatrical genius of Mr. Irving himself. The effectiveness of the play was recognized at once, even apart from the fine acting of Mr. Irving as Mephistopheles and Miss Terry as Margaret. Following Irving's example, Lewis Morrison prepared a version of *Faust* which he used on his tours for twenty years up to the time of his death. In this way many an American small town saw a performance of *Faust* which was very creditable, for Mr. Morrison was an actor and manager of fine ability, and his play was a good piece of work.

In 1842, a play was produced in Germany from the pen of Friedrich Halm, called *The Son of the Wilderness*. Translated by Mrs. Maria Lovell into English under the title of *Ingomar*, this play has been a great favorite in its time on the American stage. The character of Ingomar the Barbarian has appealed to actors of such talent as Salvini

and John McCullough, and the rôle of the gentle Parthenia has served to introduce some famous actresses to the American stage. Though the play now seems stilted and old fashioned on reading, yet a fragrant memory hovers about it to one who remembers the girlish grace of Julia Marlowe, then in her first season on the stage, and the radiant loveliness of Mary Anderson still in her teens. All persons who quote poetry at all know the lines

Two souls with but a single thought
Two hearts that beat as one.

One more play remains to be spoken of among the old-fashioned German dramas. This is the *Deborah* (1849) of Salomon Hermann von Mosenthal (1821-77). Under its original title it was in the repertory of Mme. Janauschek, but since the early eighties, when Margaret Mather appeared in the play, it has been known as *Leah the Forsaken*. The rôle of the unhappy Jewess is very effective, especially so in the famous curse scene, as can be inferred from the fact that that gifted actress, Miss Nance O'Neil, has recently been using this scene successfully as a twenty minute vaudeville "turn."

In the late sixties a grand spectacular play from the German was produced in this country by the famous Kiralfy Brothers. This play was adapted from an old fairy tale and dealt with the persecution, adventures and final reunion of a pair of perfect lovers, the poor artist, Rudolph, and the village beauty, Amina. Pursued by the evil machinations of the villain aided by a magician, the young couple were nevertheless protected by the queen of the fairies, and virtue triumphed over evil. The curtain falls on a vision of the enchanted home of the fairies. The foregoing description sounds innocent and harmless, yet in its day *The Black Crook* was denounced as wicked, vile and harmful, in short a menace to public morals. The free advertising thus received of course acted then as it does now, when some play is sensationally denounced and thereby exploited by a hypocritical yellow press and eager managers. It stimulated curiosity and made of *The Black Crook* one of the biggest sensations and money-earners in the history of the American stage. Even today barn-storming companies, trading on the remains of the unsavory reputation of *The Black Crook* forty years ago, do

not hesitate to start out with the piece, or at least with an entertainment bearing the name, and earn good money in the prurient back counties of the Mississippi Valley. But what was all the original hue and cry about? In what did the wickedness of this play consist? Simply in the fact that *The Black Crook* introduced the ballet for the first time on the American stage. It should here be stated that the dancing was of the highest degree of excellence. The poetry of motion had never been realized so completely before, as in these bewildering Hungarian ballets. No manager since has surpassed the Kiralfy Brothers in the beauty of the stage setting. The objection to *The Black Crook* in the sixties was to the short skirts and tights, an objection seldom raised nowadays. Indeed in many a modern musical comedy the hardened theater-goer often sees vulgar dancing, which makes the old ballet divertissement of *The Black Crook* seem like a lesson in deportment.

During the eighties in New York Daly's Theater was the favorite resort of people of taste. Augustin Daly, though famous as a producer of Shakespeare and the poetic drama, nevertheless achieved permanent fame by his presentations of wholesome German farce comedies. For many of his most successful plays he was indebted to Franz von Schönthan (1849-). Owing to his complete change of title and scene in many instances, it is difficult to learn from an American theater program, what the original name of the play was, from which Mr. Daly made his adaptation. But in the palmy days of John Drew, Ada Rehan, James Lewis and Mrs. Gilbert, some of Schönthan's plays were given very delightful productions, especially *The Lottery of Love*, *An International Match*, and *A Night Off*. The last named seems to have won a permanent place in the repertory of stock companies throughout the country.

Shortly before the advent of Schönthan, a dramatist held sway, whose work ranks high in the realm of comedy, Gustav von Moser (1825-1903.) He is known to us through *The Private Secretary* (1878), a hilarious farce, adapted to our stage in 1882 by Mr. William Gillette, who played the title rôle and came prominently into notice at that time. This play too has been given by many stock companies with great success.

The year 1882 marks the first appearance as a dramatic author of Ernst von Wildenbruch (1845-). He is one of the most prominent living modern German dramatists, yet to us he is known by only one play, *Die Haubenlerche* (1891), from which the late Clyde Fitch, a few years ago, adapted *The Bird in the Cage* for Miss Annie Russell. Though a strong modern play in good standing in Germany, it seems to have made no lasting impression in this country.

In 1889, an author came to the fore in Germany who has since dominated the German stage. This was Herman Sudermann (1857-). The only dramatist who may be said to share his reputation is Gerhart Hauptmann (1862-). These two are the great names at the beginning of the twentieth century.

Of the dozen plays of Sudermann, four have been given in this country, *Heimath* (1893) under the title of *Magda*, *John the Baptist* (1898), *The Fires of St. John* (1900) and *Es lebe das Leben* (1902) under the title of *The Joy of Living*. Of these plays only *Magda* seems to have maintained itself in the public interest. Madame Modjeska was the first to produce it, when it was still a novelty in Germany. Mrs. Patrick Campbell and Miss Nance O'Neil have since appeared as the heroine. The rôle has been acted in French by Madame Sarah Bernhardt and in Italian by Madame Eleanora Duse. With this play Sudermann may be said to have achieved international fame. *John the Baptist* (1898) was produced by Mr. E. H. Sothorn and Miss Julia Marlowe. The interest in the play was enhanced by the furore caused about the same time by the production of Richard Strauss's opera *Salome*.

The Fires of St. John (1900) was for a time in the repertory of Miss Nance O'Neil.

The Joy of Living (*Es lebe das Leben*, 1902) was the chief offering of Mrs. Patrick Campbell on one of her late tours.

Of the plays of Gerhart Hauptmann, only two interest us from our present point of view, *Hannele* (1894), produced about fifteen years ago by Madame Modjeska and possibly to be revived soon by Miss Maude Adams, and *The Sunken Bell* (1896), produced about ten years ago by Mr. E. H. Sothorn, and revived later by him in conjunction with

Miss Julia Marlowe in splendid style. Both of these plays are for the more serious minded class of theater-goers. Their mysticism is not calculated to appeal to the frivolous amusement seeker.

There are a few other German plays which have been seen upon the American stage of recent years, which are deserving of more than passing mention. One of these, the *Old Heidelberg* (1890) of Wilhelm Meyer-Förster (1862-) first given in this country by Richard Mansfield, has since taken its place in the repertory of the stock company theaters the country over. The other is the biblical drama *Mary of Magdala* (1899) by Paul Heyse, which was given a most impressive production by Mrs. Minnie Maddern Fiske. The performance of this play in Germany is still forbidden by the censor.

On the whole, if Germany has not furnished the American stage with as many well-known and popular plays as has France, the number is nevertheless considerable, and that there has been much plagiarism from Germany, there can be no doubt. Many a German farce with an unpronounceable title is made over into an American play with American scenes and names. Sometimes a vague acknowledgment by the American adapter is made. Two of his recent successes, *The Blue Mouse* and *Girls*, Clyde Fitch adapted from the German of Alexander Engle and Julius Horn, though in view of the very American character of *Girls* it is hard to imagine what the German original must have been like.

Anyone really interested in the German drama, if he understands the language, cannot do better than patronize the German theaters in the larger cities of the United States having a considerable German population. New York has for many years had a German theater, the Irving Place Theater, where the performances are of the best; and in Philadelphia, Buffalo, Chicago, Milwaukee and St. Louis, there are excellent performances in German. In the smaller cities there are occasional performances sometimes by semi-amateur organizations, which are given on Sunday evenings. The repertory is kept remarkably up to date, and plays are given which are still regarded as novelties in Germany. A few years ago *Der Hochtourist* was given in Denver, by the local German company, while Mr. Francis Wilson was enter-

taining his audiences about the country with an English version of the same play under the title of *The Mountain Climber*.

On the whole the modern dramatic output in Germany is of very satisfactory quality. Especially in the field of operetta, Berlin and Vienna have long since distanced Paris. In the drama they are already formidable rivals, and the outlook for the future is encouraging.

BORROWINGS AND ADAPTATIONS FROM THE "ILIAD" AND "ODYSSEY" IN MATTHEW ARNOLD'S "SOHRAB AND RUSTUM"¹

BY MILO G. DERHAM

It has more than once been suggested to me that I should translate Homer. This is a task for which I have neither the time nor the courage; but the suggestion led me to regard yet more closely a poet whom I had already studied, and for one or two years the works of Homer were seldom out of my hands.—ARNOLD, *On Translating Homer*.

Matthew Arnold fulfilled the precept of Horace. He turned over his Greek models by day and by night. He brought everything to the classical touchstone. Whatever was not Greek was barbarian.

Far more truly Homeric than Clough's jolting hexameters it ("Sohrab and Rustum") is as good a specimen of Homer's manner as can be found in English.—HERBERT PAUL, *Matthew Arnold*, pp. 3 and 46.

In the selections here given from "Sohrab and Rustum," the page numbers refer to the Globe Edition of *Matthew Arnold's Poems* (The Macmillan Company, New York, 1903). Lang, Leaf and Myer's translation of the *Iliad*, and Palmer's translation of the *Odyssey* supply the renderings of Homer.

Page 65:

—the men were plunged in sleep;
Sohrab alone, he slept not; all night long
He had lain wakeful, tossing on his bed.

Compare *Il.* 24:2 ff.: "The rest bethought them of supper and sweet sleep to have joy thereof; but Achilles wept, remembering his dear comrade, nor did sleep that conquereth all take hold on him, but he kept turning him to this side and to that." Compare also *Il.* 10:1 ff.: "Now beside the ships the other leaders of the whole Achaean host were sleeping all night long, by soft Sleep overcome, but Agamemnon, son of Atreus, shepherd of the host, sweet Sleep held not, so many things he debated in his mind."

Through the black Tartar tents he passed, which stood
Clustering like bee hives on the low flat strand.

¹ Classical elements in Matthew Arnold's poems have been pointed out by CHURTON COLLINS, *Matthew Arnold's Merope and Sophocles' Electra*, Oxford, 1906; Professor W. P. MUSTARD, "Homeric Echoes in Arnold's 'Balder Dead,'" in *Studies in Honor of Basil L. Gildersleeve*, Baltimore, 1902; and a number of parallel passages have been incorporated in Professor PAUL SHOREY's notes in his edition of Horace's *Odes and Epodes*, Boston, 1899.

Although the picture is different, these lines recall *Il.* 2:87 ff.: "Even as when the tribes of thronging bees issue from some hollow rock, ever in fresh procession, and fly clustering among the flowers of spring, and some on this hand and some on that fly thick; even so from ships and huts before the low beach marched forth their many tribes by companies to the place of assembly."

Page 66:

And Sohrab came there, and went in, and stood

is Homeric in presenting a situation by a group of three specific statements, while the verses just below

And found the old man sleeping on his bed
Of rugs and felts, and near him lay his arms

resemble *Il.* 10:73 ff.: "Then went he himself after Nestor, the shepherd of the host, whom he found by his hut and black ship, in his soft bed; beside him lay his fair dight arms, a shield, and two spears, and a shining helmet."

Pages 66 f.:

Let the two armies rest today; but I
Will challenge forth the bravest Persian lords,
To meet me, man to man.

These lines show the influence of *Il.* 7:49 ff.: "Make the other Trojans sit, and all the Achaeans, and thyself challenge him that is best of the Achaeans to meet thee man to man in deadly combat."

Page 67: The remonstrance,

O Sohrab, an unquiet heart is thine!
Canst thou not rest among the Tartar chiefs,
And share the battle's common chance with us

is not very different from that in *Il.* 3:60: "Hector, . . . thy heart is ever keen;" and in *Il.* 20:376 f.: "Hector, no longer challenge Achilles at all before the lines, but in the throng await him and from amid the roar of battle." The "battle's common chance" may be compared with the Homeric, "equal war," *Il.* 13:358, 635; 18:242.

But now he keeps apart, and sits at home.

Compare *Il.* 1:349: "Then Achilles . . . sat him down apart, aloof from his comrades."

—Yet my heart forbodes
Danger or death.

Compare *Ody.* 14:219: "My swelling heart cast not a look on death."
Page 68:

And o'er his chilly limbs his woolen coat
He pass'd, and tied his sandals on his feet,
And threw a white cloak round him, and he took
In his right hand a ruler's staff, no sword.

Compare *Il.* 10:21 ff.: "Then he rose and did on his doublet about his breast, and beneath his shining feet he bound on fair sandals, and thereafter clad him in a tawny skin of a lion fiery and great, a skin that reached to the feet, and he grasped his spear."

From their black tents, long files of horse, they stream'd;
As when some grey November morn the files,
In marching order spread, of long neck'd cranes
Stream over Casbin and the southern slopes
Of Elburz, from the Aralian estuaries,
Or some frore Caspian reed-bed, southward bound
For the warm Persian sea-board—so they stream'd.

These verses have much in common with *Il.* 2:459 ff.: "And as the many tribes of feathered birds, wild geese or cranes or long-necked swans, on the Asian mead by Kaystrios' stream, fly hither and thither joying in their plumage, and with loud cries settle ever onwards, and the mead resounds; even so poured forth the many tribes of warriors from ships and huts into the Skamandrian plain."

Pages 69 f.:

As, in a country, on a morn in June,
When the dew glistens on the pearled ears,
A shiver runs through the deep corn for joy—
So, when they heard what Peran-Wisa said,
A thrill through all the Tartar squadron ran
Of pride and hope for Sohrab, whom they loved.

Compare *Il.* 23:597 ff.: "And his heart was gladdened as when the dew cometh upon the ears of ripening harvest-corn, what time the fields are

bristling. So gladdened was thy soul, Menelaus, within thy heart." Compare also *Il.* 2:147 ff.: "And even as when the west wind cometh to stir a deep cornfield with violent blast, and the ears bow down, so was all the assembly stirred."

Page 70:

And to Ferood his brother chiefs came up
To counsel; Gudurz and Zoarrah came,
And Feraburz, who ruled the Persian host
Second, and was the uncle of the King;
These came and counsell'd, and then Gudurz said.

This counsel scene is similar to that in *Il.* 2:403 ff.: "Agamemnon . . . called the elders, the princes of the Achaean host, Nestor first and king Idomeneus, and then the two Aiantes and Tydeus' son, and sixthly Odysseus peer of Zeus in counsel. And Menelaus of the loud war-cry came to him, unbidden, for he knew in his heart, how his brother toiled."

—Aloof he sits

And sullen, and has pitch'd his tents apart.

.
Haply he will forget his wrath and fight.

The phraseology brings to mind the picture of Ajax in the lower world, *Ody.* 11:543 ff.: "Only the spirit of Ajax, son of Telamon, held aloof, still angry at the victory I gained in the contest at the ships for the arms of Achilles. . . . To him I spoke in gentle words and said: 'Ajax, son of gallant Telamon, will you not, even in death, forget your wrath about the accursed armor?'"

Pages 70 f.:

He spake: and Peran-Wisa turn'd and strode
Back through the opening squadrons to his tent.

Compare *Ody.* 11:538 ff.: "So I spoke, and the spirit of the swift-footed Aeacides departed with long strides across the fields of Asphodel."

Page 71:

But through the anxious Persians Gudurz ran,
And cross'd the camp which lay behind, and reach'd,
Out on the sands beyond it, Rustum's tents.
.
And Gudurz enter'd Rustum's tent and found
Rustum;

.
 and there Rustum sate
 Listless, and held a falcon on his wrist,
 And play'd with it; but Gudurz came and stood
 Before him; and he look'd, and saw him stand,
 And with a cry sprang up and dropp'd the bird,
 And greeted Gudurz with both hands and said:—
 "Welcome! these eyes could see no better sight.
 What news? but sit down first, and eat and drink."

Though not a close imitation of Homer, this passage has much in common with the story of the embassy of Odysseus and Ajax to Achilles, *Il.* 9:182 ff.: "So the twain went along the shore of the loud-sounding sea. . . . They came to the huts and ships of the Myrmidons, and found the king taking his pleasure of a loud lyre. . . . So the twain came forward . . . and they stood before his face; and Achilles sprang up amazed with the lyre in his hand, and left the seat where he was sitting. . . . Then Achilles . . . greeted them and said: 'Welcome; verily ye are friends that are come—sore indeed is the need—even ye that are dearest of the Achaeans to me even in my wrath.'

"So spake noble Achilles and led them forward, and made them sit on settles and carpets of purple; and anon he spake to Patroklos being near: 'Bring forth a greater bowl, thou son of Menoitios; mingle stronger drink, and prepare each man a cup, for dearest of men are these that are under my roof.'"

The last line of the above quotation from "Sohrab and Rustum" reflects the Homeric custom of first entertaining guests and then questioning them. Compare *Ody.* 3:69 ff.: "Now, then, it is more suitable to prove our guests and ask them who they are, since they are refreshed with food. Strangers, who are you? Where do you come from, sailing the watery ways? Are you upon some business? Or do you rove at random, as the pirates roam the seas, risking their lives and bringing ill to strangers?"

Page 72:

And I to tarry with the snow-hair'd Zal
 My father, whom the robber Afgans vex,
 And clip his borders short, and drive his herds,
 And he has none to guard his weak old age.

There would I go, and hang my armour up,
And with my great name fence that weak old man.

This passage portrays defenseless old age in the same spirit as *Ody.* 11: 494 ff., where Achilles' lament in the lower world is given: "Tell what you know of gallant Peleus whether he still has honor in the cities of the Myrmidons; or do they slight him now in Hellas and in Phthia, because old age has touched his hands and feet? I am myself no longer in the sunlight to defend him, nor like what I once was when on the Trojan plain I routed a brave troop in succoring the Argives. If once like that I could but come, even for a little space, into my father's house, frightful should be my might and my resistless hands to any who are troubling him and keeping him from honor." Compare also *Ody.* 11:187 ff.; 24: 224 ff.; *Il.* 18:434 f.; 19:334 ff.; 24:540 ff.

And with these slaughterous hands draw sword no more.

The expression "slaughterous hands" is the same as Homer's "man-slaying hands," *Il.* 18:317; 23:18; 24:479.

And greatly moved, then Rustum made reply:—
"O, Gudurz, wherefore dost thou say such words?
Thou knowest better words than this to say."

Compare *Il.* 12:230 ff.: "Then Hector of the glancing helm lowered on him and said: 'Polydamus, that thou speakest is no longer pleasing to me; yea, thou knowest how to conceive another counsel better than this.'" Compare also *Il.* 7:356 ff.

Page 74:

And as afield the reapers cut a swath
Down through the middle of a rich man's corn,
And on each side are squares of standing corn,
And in the midst a stubble, short and bare—
So on each side were squares of men, with spears
Bristling, and in the midst, the open sand.

Though describing a different situation, this passage is a close imitation of *Il.* 11:67 ff.: "And even as when reapers over against each other drive their swathes through a rich man's field of wheat or barley, and thick fall the handfuls, even so the Trojans and Achaeans leaped upon each other destroying, and neither side took thought of ruinous flight."

Page 75:

And he ran forward and embraced his knees,
And clasp'd his hand within his own, and said.

Compare *Il.* 1:500 f.: "So she sat before his face and with her left hand clasped his knees." Compare *Il.* 6:253 (=406): "and she clasped her hand in his, and spake, and called upon his name."

But Rustum eyed askance the kneeling youth,
And turn'd away, and spake to his own soul.

Compare *Il.* 1:148: "Then eyeing him askance the fleet-footed Achilles addressed him." Compare also *Il.* 22:98: "Then sore troubled he spake to his great heart."

Pages 75 f.: The scene in which Rustum ponders on the probable result of a reconciliation with Sohrab is in the manner of the episode of Glaucos and Diomedes, *Il.* 6:212 ff. The lines

—and proffer courteous gifts
A belt or sword perhaps, and go his way,

and

—then he and I
Changed gifts, and went on equal terms away,

are echoes of *Il.* 6:218 f.: "They gave each other goodly gifts of friendship: Oineus gave a belt bright with purple, and Bellerophon a gold twy-handled cup;" and of *Il.* 6:226 f.: "So let us shun each other's spears, even amid the throng. . . . But let us make exchange of arms between us."

Page 76:

So will he speak perhaps, while men applaud.

Compare *Il.* 3:461: "So said Atreides, and all the Achaeans gave assent." Compare also *Ody.* 12:294, 352.

Rash boy, men look on Sohrab's face and flee!

This recalls Homer's use of *σχέτλιος*, *Il.* 3:414; *Ody.* 9:494; 12:21, etc.

Or else thy bones shall strew this sand, till winds
Blanch them, or Oxus with his summer-floods,
Oxus in summer wash them all away.

This is apparently a free imitation of *Ody.* 1:160 f.: "They eat the sub-

stance of a man whose white bones now are rotting in the rain, if lying on the land, or in the sea the waters roll them round."

Page 77:

But yet success sways with the breath of heaven.

Compare *Il.* 6:339: "For victory shifteth from man to man."

He spoke, and Rustum answer'd not, but hurl'd

His spear;

. . . . Sohrab saw it come

And sprang aside, quick as a flash; the spear

Hiss'd, and went quivering down into the sand,

Which it sent flying wide;—then Sohrab threw

In turn, and full struck Rustum's shield; sharp rang,

The iron plates rang sharp, but turn'd the spear.

And Rustum seized his club, which none but he

Could wield; an unlopp'd trunk it was, and huge,

Still rough,—like those which men in treeless plains

To build them boats fish from the flooded rivers,

.

So huge

The club which Rustum lifted now, and struck

One stroke; and again Sohrab sprang aside,

Lithe as the glancing snake and the club came

Thundering to earth, and leapt from Rustum's hand.

The above passage shows a skilful independent combination of various Homeric elements with much that is original. Compare *Il.* 22:273 ff.: "He said, and poised his far shadowing spear and hurled. And noble Hector watched the coming thereof and avoided it; for with his eye on it he crouched, and the bronze spear flew over him, and fixed itself in the earth." (Compare *Il.* 13:402 ff; 17:525 ff.) Compare also *Il.* 7:258 ff.: "Then Priam's son smote the shield's midst with his dart, but the bronze brake not through, for the point turned back: but Aias leapt on him and pierced his buckler, and straight through went the spear. . . . Yet even then did not Hector of the glancing helm cease from fight, but yielded ground and with stout hand seized a stone lying upon the plain, black and rugged and great; therewith hurled he and smote Aias' dread shield of sevenfold oxhide in the midst upon the boss, and the bronze resounded. Next Aias lifted a far greater stone, and swung

and hurled it, putting might immeasurable therein." Compare also *Il.* 16:139 ff.: "Then seized he two strong lances that fitted his grasp, only he took not the spear of the noble son of Aiakos, heavy, and huge, and stalwart, that none other of the Achaeans could wield, but Achilles alone availed to wield it; even the ashen Pelian spear that Cheiron gave to his father dear, from a peak of Pelion, to be the death of warriors." Compare also *Ody.* 9:319 ff.: "There lay beside the pen a great club of the Cyclops, an olive stick still green, which he had cut to be his staff when dried. Inspecting it, we guessed its size and thought it like the mast of a black ship of twenty oars—some broad-built merchantman which sails the great gulf of the sea; so huge it looked in length and thickness."

Page 78:

Come plant we here in earth our angry spears,
 And make a truce, and sit upon this sand,
 And pledge each other in red wine, like friends,
 And thou shalt talk to me of Rustum's deeds.
 There are enough foes in the Persian host,
 Whom I may meet, and strike, and feel no pang;
 Champions enough Afrasiab has, whom thou
 Mayst fight; fight *them*, when they confront thy spear!
 But oh, let there be peace 'twixt thee and me!

Compare *Il.* 6:212 ff.: "So said he, and Diomedes of the loud war-cry was glad. He planted his spear in the bounteous earth and with soft words spake to the shepherd of the host: 'Surely then thou art to me a guest friend of old times through my father. . . . So let us shun each other's spears, even amid the throng; Trojans are there in multitudes and famous allies for me to slay, whoe'er it be that God vouchsafeth me and my feet overtake; and for thee are there Achaeans in multitude, to slay whome'er thou canst.'"

Page 79:

Blazed bright and baleful, like that autumn-star
 The baleful sign of fevers.

Compare *Il.* 22:26 ff.: "Blazing as the star that cometh forth at harvest-time, and plain seen his rays shine forth amid the host of stars in the darkness of night, the star whose name men call Orion's Dog. Brightest

of all is he, yet for an evil sign is he set, and bringeth much fever upon hapless men."

Girl, nimble with thy feet, not with thy hands!
Curl'd minion, dancer, coiner of sweet words!
Fight, let me hear thy hateful voice no more!

This is in the tone of *Il.* 22:279 ff.: "Thou hast missed, so no wise yet, godlike Achilles, hast thou known from Zeus the hour of my doom, though thou thoughtest it. Cunning of tongue art thou, and a deceiver in speech, that fearing thee I might forget my valor and strength." With the thought of the passage from Arnold may be compared Vergil, *Aen.* 11:390 f.: "Will your prowess always lie in your blustering tongue, and in those feet only swift to fly?"

Speak not to me of truce, and pledge, and wine!
Remember all thy valour; try thy feints
And cunning! all the pity I had is gone;
Because thou hast shamed me before both the hosts
With thy light skipping tricks, and thy girl's wiles.

This is an adaptation of *Il.* 22:261 ff.: "Hector, talk not to me, thou madman, of covenants. . . . Bethink thee of all thy soldiership: now behooveth it thee to quit thee as a good spearman and valiant man of war. No longer is there way of escape for thee, but Pallas Athene will straightway subdue thee to my spear; and now in one hour shalt thou pay back for all my sorrows for my friends whom thou hast slain, in the fury of thy spear."

—at once they rush'd
Together, as two eagles on one prey
Come rushing down together from the clouds,
One from the east, one from the west.

These lines remind one of two passages in Homer, *Il.* 22:308 ff., and *Ody.* 2:146 ff., because of their Homeric tone, although the situation is different and the verbal resemblance is not marked.

Pages 79 f.:

And you would say that sun and stars took part
In that unnatural conflict; for a cloud
Grew suddenly in Heaven, and dark'd the sun
Over the fighters' heads; and a wind rose
Under their feet, and moaning swept the plain,
And in a sandy whirlwind wrapp'd the pair.

In gloom they twain were wrapp'd, and they alone;
 For both the on-looking hosts on either hand
 Stood in broad daylight, and the sky was pure,
 And the sun sparkled on the Oxus stream,
 But in the gloom they fought with bloodshot eyes
 And labouring breath.

These lines were evidently suggested by the passage in *Il.* 17:366 ff.: "Thus strove they as it had been fire, nor wouldst thou have thought there was still sun or moon, for over all the battle where the chiefs stood around the slain son of Menoitios they were shrouded in darkness, while the other Trojans and well-greaved Achaeans fought at ease in the clear air, and piercing sunlight was spread over them, and on all the earth and hills there was no cloud seen. . . . But they who were in the midst endured affliction of darkness and the battle, and all the best men of them were wearied by pitiless weight of their bronze arms."

Page 80:

—but this time all the blade, like glass,
 Sprang in a thousand shivers on the helm,
 And in the hand the hilt remain'd alone.

This is a variation of Homer's lines, *Il.* 3:362 f.: "But the sword shattered upon it into three, yea, four, and fell from his hand." (Compare *Il.* 16:338 f.)

—his dreadful eyes
 Glared, and he shook on high his menacing spear.

This recalls the Homeric picture of Athena, *Il.* 1:200: "And terribly shone her eyes." "Menacing spear" recalls Vergil's "menacing spear" (*Aen.* 10:877).

Page 81:

Sohrab, thou thoughtest in thy mind to kill
 A Persian lord this day, and strip his corpse.

One may compare for a similar taunting speech of one hero to another, *Il.* 22:279 f.: "Thou hast missed, so no wise yet, godlike Achilles, hast thou known from Zeus the hour of my doom though thou thoughtest it." Compare also *Il.* 22:331; 16:830.

Dearer to the red jackals shalt thou be
 Than to thy friends, and to thy father old.

In Homer, we find, *Il.* 11:161 f.: "But they on the earth were lying, far more dear to the vultures than to their wives."

—Yet thy fierce boast is vain.
 Thou didst not slay me, proud and boastful man!
 No! Rustum slays me and this filial heart.
 For were I match'd with ten such men as thee,
 And I were that which till today I was,
 They should be lying here, I standing there,
 But that belovéd name unnerved my arm—

 and thy spear transfix'd an unarm'd foe.

Here is plainly a free adaptation of Patroklos' dying words, *Il.* 16:844 ff.: "Boast greatly, as now Hector, for to thee have Zeus, son of Kronos, and Apollo given the victory, who lightly have subdued me; for themselves stripped my harness from my shoulders. But if twenty such as thou had encountered me, here had they all perished, subdued beneath my spear. But me have ruinous Fate and the son of Leto slain, and of men Euphorbos, but thou art third in my slaying."

Page 82:

And with failing voice, Sohrab replied.

Compare *Il.* 16:843: "Then faintly didst thou answer him, Patroklos."

Compare *Il.* 15:246; 22:337.

Page 83:

Yet him I pity not so much, but her,
 My mother who in Ader-baijan dwells
 With that old king, her father, who grows grey
 With age, and rules over the valiant Koords.
 Her most I pity, who no more will see
 Sohrab returning from the Tartar camp,
 With spoils and honour, when the war is done.

Compare Hector's words, *Il.* 6:450 ff.: "Yet doth the anguish of the Trojans hereafter not so much trouble me, neither Hekabe's own, neither King Priam's, neither my brethren's, . . . as doth thine anguish in the day when some mail-clad Achaean shall lead thee weeping and rob thee of the light of freedom," and Hector's prayer, *Il.* 6:479 ff.: "And then may men say of him, 'Far greater is he than his father' as he return-

eth home from battles; and may he bring with him bloodstained spoils from the foeman he hath slain, and may his mother's heart be glad."

Page 84:

—one child he had—
But one—a girl; who with her mother now
Plies some light female task, nor dreams of us—
Of us she dreams not, nor of wounds nor war.

Several passages in Homer contrast the domestic tasks of woman and the sterner business of counsel and war falling to the lot of man. Compare *Ody.* 21:350 ff.: "Then seek your chamber, and attend to matters of your own,—the loom and distaff,—and bid the women ply their tasks. Bows are for men, for all, especially for me." Compare also *Ody.* 1:356 ff.; *Il.* 6:490 ff.

Page 85:

The anguish of the deep-fix'd spear grew fierce,
And he desired to draw forth the steel,
And let the blood flow free, and so to die.

Death follows immediately after the removal of the spear point, and in Homer the soul at times seems to depart through the wound, *Il.* 16:502 ff.: "Even as he spoke thus the end of death veiled over his eyes and his nostrils, but Patroklos, setting foot on his breast, drew the spear out of his flesh, and the midriff followed with the spear so that he drew forth together the spear point, and the soul of Sarpedon."

Then with weak and hasty fingers, Sohrab loosed
His belt, and near the shoulder bared his arm,
And show'd a sign in faint vermilion points
Prick'd; as a cunning workman, in Pekin,
Pricks with vermilion some clear porcelain vase,
An emperor's gift—at early morn he paints,
And all day long, and, when night comes, the lamp
Lights up his studious forehead and thin hands—
So delicately prick'd the sign appear'd
On Sohrab's arm, the sign of Rustum's seal.

The above simile has been compared for its verbal similarity as well as for the Homeric addition of picturesque details to *Il.* 4:141 ff.: "As when some woman of Maionia or Karia staineth ivory with purple, to make a cheek-piece for horses, and it is laid up in the treasure chamber,

and many a horseman prayeth for it to wear; but it is laid up to be a king's boast, alike an adornment for his horse and a glory for his charioteer; even in such wise, Menelaos, were thy shapely thighs stained with blood and thy legs and thy fair ankles beneath." Vergil (*Aen.* 12:67 f.) borrowed the Homeric simile, applying it to a blushing maiden: "As if one had stained Indian ivory with ruddy purple."

Page 86:

And then a dark cloud pass'd before his eyes,
And his head swam, and he sank down to earth.

This may be compared with *Il.* 22:466 ff.: "Then dark night came on her eyes and shrouded her, and she fell backward and gasped forth her spirit." Compare also such passages as *Il.* 4:503 ff.

—and he seized

In both his hands the dust which lay around,
And threw it on his head, and smirch'd his hair,—
His hair, and face, and beard, and glittering arms;
And strong convulsive groanings shook his breast,
And his sobs choked him.

The description of Rustum's grief for his son is very similar to the picture of Achilles bewailing his friend Patroklos, *Il.* 18:22 ff.: "Thus spake he, and a black cloud of grief enwrapped Achilles, and with both hands he took dark dust and poured it over his head, and defiled his comely face, and on his fragrant doublet black ashes fell. And himself in the dust lay mighty and mightily fallen, and with his own hands tore and marred his hair. . . . Then terribly mourned Achilles."

Arnold's "glittering arms" like Vergil's *arma radiantia* is borrowed from *Il.* 18:617.

—I but meet today

The doom which at my birth was written down
In Heaven.

The belief in fatalism occurs frequently in Homer, as in *Ody.* 7:196 ff.: "There, in the days to come, he shall receive whatever fate and the stern spinners wove in his birth-thread when his mother bore him." Compare also *Il.* 3:308 f.: "Zeus knoweth, and all the immortal Gods, for whether of the twain the doom of death is appointed." Compare also *Il.* 6:487 ff.; 16:441 f.; 20:127 f.; Vergil, *Aen.* 10:467.

Page 87:

Come, sit beside me on this sand, and take
My head betwixt thy hands, and kiss my cheeks,
And wash them with thy tears, and say: *My Son!*

It is possible that this passage shows the influence of *Il.* 18:70 ff.: "And as he groaned heavily his lady mother stood beside him, and with a shrill cry clasped the head of her child, and spake unto him winged words of lamentation: 'My child,' " etc. Compare also *Il.* 24:723 ff.

—and Ruksh, the horse,
With his head bowing to the ground and mane
Sweeping the dust, came near, and in mute woe
First to the one then to the other moved
His head, as if inquiring what their grief
Might mean; and from his dark compassionate eyes,
The big warm tears roll'd down, and caked the sand.

The "mute woe" of Ruksh is described in words which represent a free borrowing from the story of the grief of Achilles' horses, Balios and Xanthos, once "endowed with human speech," over the death of Patroklos, *Il.* 17:426 ff.: "But the horses of Aeakides that were apart from the battle, were weeping, since first they were aware that their charioteer had fallen. . . . So abode they immovably with the beautiful chariot abasing their heads unto the earth. And hot tears flowed from their eyes to the ground as they mourned in sorrow for their charioteer, and their rich manes were soiled as they drooped from beneath the yoke cushion on both sides beside the yoke." Compare also *Il.* 19:404 ff. In "big warm tears," Arnold has combined two Homeric epithets occurring separately. The expression "big tears" is found in *Il.* 24:9; "warm tears" in *Il.* 17:437, 438. The expression "caked the sand" calls up *Il.* 23:15 f.: "Bedewed were the sands with tears, bedewed the warriors' arms."

Page 88:

Then with heavy groan, Rustum bewail'd.

There are many lines in Homer very similar to this one. Compare *Il.* 1:364: "Then with heavy moan, Achilles, fleet of foot spake to her."

Oh, that its waves were flowing over me!
 Oh, that I saw its grains of yellow silt
 Roll tumbling in the current o'er my head!

In these lines, Arnold was evidently influenced by Helen's "gentle words," *Il.* 6:345 ff.: "Would that on the day when my mother bore me at the first, an evil storm-wind had caught me away to a mountain or a billow of the loud-sounding sea, where the billow might have swept me away before all these things came to pass." Compare Tennyson's adaptation, in "A Dream of Fair Women"—

I would the white cold heavy plunging foam,
 Whirl'd by the wind, had roll'd me deep below,
 Then when I left my home.

Page 89:

Fear not! as thou hast said, Sohrab, my son,
 So shall it be; for I will burn my tents,
 And quit the host, and bear thee hence with me,
 And carry thee away to Seistan,
 And place thee on a bed, and mourn for thee,
 With the snow-headed Zal, and all my friends.
 And I will lay thee in that lovely earth,
 And heap a stately mound above thy bones,
 And plant a far-seen pillar over all,
 And men shall not forget thee in thy grave.

No other passage in "Sohrab and Rustum" illustrates better Arnold's complete absorption of the Homeric manner and the skill and felicity with which he constantly combined detached Homeric phrases, and situations drawn or adapted from various parts of the poems, into a harmonious whole. In accordance with the Homeric manner this speech of Rustum is a repetition, *mutatis mutandis*, of the words of Sohrab, the other party to the dialogue. The Homeric passages drawn upon are *Il.* 24:669 ff.: "All this, O ancient Priam, shall be as thou biddest; for I will hold back the battle even so long a time as thou tellest me;" *Il.* 22:352 ff.: "Not even so shall thy lady mother lay thee on a bed and mourn her son" (compare *Il.* 22:86 f.); and *Il.* 16:671 ff.: "And send him to be wafted by fleet convoy, by the twin brothers Sleep and Death, that quickly will set him in the land of wide Lycia. There will his kins-

man and clansman give him burial, with barrow and pillar, for such is the due of the dead." Compare also *Il.* 11:371; 16:457; 17:434 f.; *Ody.* 12:14 f. "That lovely earth" recalls Homer's frequent use of the adjective *ἐπατεινός*, applied to countries and cities, as in *Ody.* 7:79: "lovely Scheria;" *Il.* 3:239: "lovely Lakedaimon."

Page 91:

Till now all strength was ebb'd and from his limbs
Unwillingly the spirit fled away,
Regretting the warm mansion which it left,
And youth and bloom, and this delightful world.

Compare *Il.* 16:855 ff.: "Even as he spoke, the end of death overshadowed him. And his soul, fleeing from his limbs, went down to the home of Hades, wailing its doom, leaving manhood and youth." Compare also *Il.* 22:361 ff.

THE UNIVERSITY OF COLORADO MOUNTAIN LABORATORY

BY FRANCIS RAMALEY

The mountain laboratory at Tolland, Colo. (attitude 8,889 feet), is maintained for the field study of biology: plants, birds, insects and mammals. In the summer of 1909, from June 14 to July 30, the first session



FIG. 1.—Map of Colorado showing location of Tolland, the seat of the mountain laboratory. Its nearness to Denver and to the university at Boulder is apparent.

was held. This proved so successful that it was determined to continue the sessions in subsequent years. It was found that the courses which had been planned were well adapted to conditions at the laboratory and they were carried out to the satisfaction of all concerned. Students and instructors worked together on a number of special problems as well as in regular class work.

In choosing the location for the laboratory attention was given to accessibility, suitable climate and richness of flora and fauna. Tolland¹ is a mountain hamlet of less than two score buildings but is provided with excellent train service by standard gauge railway and also post-office, express and telegraph facilities, good hotel, lodging-houses and restaurant. There are two general stores. Gold mining and timber cutting are the chief industries of the country 'round, the cool summers not permitting agriculture. Only five miles down the valley there are, however, mountain ranches which produce hay and grain.

The laboratory differs from other biological stations in offering special opportunities for field study of plant distribution in different climates. At Tolland the summer is cool, with a mean July temperature of about 58° F., while within an hour's ride by railway down the valley to the foothills or to the edge of the plains the July mean is nearly 70°. A trip by rail of forty-five minutes takes the student to the upper limit of tree growth (timberline) with its alpine tundra and scrub willows. Almost at his door, it may be said, the student has as wide diversity in climate as could be found in a trip from Illinois to Ellesmereland. Just as in making this latter journey various zones of plant and animal life would be encountered, so in passing from arid plain to alpine height there are many belts of vegetation each with its own characteristic plants.

Although the laboratory building was originally designed for business purposes it is admirably adapted to its present use. It is well lighted from the north, is provided with ample shelf room, counters and tables and there is a large room for storage and a good photographic dark room. Jars, bottles and chemicals, plant driers, insect nets, water bath, drying oven, soil cans and soil borers are kept at the laboratory while reference books, microscopes, microtomes, forestry instruments and cameras are taken up from the university at Boulder for use during the summer session.

The village of Tolland is situated in a mountain park (Boulder Park) surrounded by mountains. South Boulder Creek, a stream fed by melting snows of the alpine peaks, flows in winding course through the

¹ See also an article in the *Plant World*, Vol. XII, pp. 105-10, by the present writer and Mr. W. W. ROBBINS for further account of Tolland and vicinity.

park, fringed by a band of meadow with swamp grass and clumps of willows. A broad area of dry grassland extends back from the creek and this is followed by pine and spruce forests on the surrounding hill-sides. A considerable extent of aspen and alder forest on a moist hill-side opposite the laboratory and a ridge covered with sage brush and various dry-country plants offer extreme conditions for plant growth. Thus in the immediate neighborhood of the laboratory, within twenty minutes' walk, there are almost unrivalled opportunities for ecological study.

From the standpoint of ornithology and mammalogy Boulder Park is not especially rich but there is opportunity here for studying some of the more common birds and mammals of the region. An abundance and variety of insects make it possible for the student to secure a good collection with a minimum amount of exertion. During the summer of 1909 a large number of specimens of insects were taken as well as many birds and some mammals.

To the student who wishes to become acquainted quickly with examples of many plant families Tolland offers a wealth of material for work. In the early spring season—which is the month of June—there are willows, alders and birches in blossom, and, somewhat later, pines and spruces. Flowering herbs are abundant and varied in character. The growing season is so short that in two months' time it is possible to observe nearly the whole flora from blooming of willows to fruiting of gentians and composites.

The laboratory is a place where those who wish to become acquainted with the outdoor side of botany and zoölogy may find instruction suited to their needs. Teachers who wish to prepare themselves for nature-study work may make collections to be used later in their schools. The advanced student, trained in laboratory work, may carry on investigations and enlarge his knowledge of plants and animals in the field. To the high-school or college instructor who wishes to broaden his horizon by intimate contact with nature and an acquaintance with mountain plants and animals opportunity is here given to learn much in a short time.

The laboratory is in no way a rival of the many excellent seaside and lakeside laboratories in various parts of the world. It occupies a unique



FIG. 3.—The mountain laboratory with a group of students. From a photograph by the author.



FIG. 4.—Looking east in Boulder Park: South Boulder Creek, dwarf willows; railway station at extreme right. From a photograph by the author.



FIG. 5.—The coniferous forest near Jenny Creek, about a half-mile from the laboratory. Photograph by the author.

position in affording opportunity for the study of the rich flora and fauna of a mountain district. Especially favored in climate and geographical position it places the student where he must appreciate the relationship which organisms bear to their environment.

The following investigations¹ were undertaken by members of the 1909 party:

1. *Plant Formations of Boulder Park and Vicinity*—to be a general account of the larger ecological associations.
2. *Pondside Vegetation*—a continuation of work started two years ago by the professor in charge and the instructor.
3. *The Lodgepole Forest*—a study of the distribution of the lodgepole pine with relation to slope, exposure, etc.; also the associated trees and herbaceous plants of the forest.
4. *An Ecological Cross-Section of Boulder Park*—examination of ten typical points as to soil moisture, soil temperature and characteristic species of plants.
5. *The Insect Visitors of Pentstemon*—collection and study of the different insects and their importance in pollination.
6. *The Habits of the Salamanders of Park Lake*—observations on breeding, relation to temperature of the water, behavior during night and day.
7. *Ants of Boulder Park*—study of habits, abundance etc. Preparation of artificial key for their identification.

¹ The unrivalled opportunities for investigation of botanical problems in Colorado are set forth in a paper entitled "Botanical Opportunity in Colorado" by the present writer published in the *University of Colorado Studies*, Vol. VI, pp. 5-10, December, 1908.

VOLUME VII

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CONTENTS

	PAGE
SCIENTIFIC EXPEDITION TO NORTHWESTERN COLORADO IN 1909	
1. ITINERARY, TOPOGRAPHY AND GEOLOGY	101
JUNIUS HENDERSON, B.A. Curator of the Museum	
2. REMARKS ON THE CLIMATOLOGY OF NORTHWESTERN COLORADO	112
W. W. ROBBINS, M.A. Instructor in Biology	
3. A BOTANICAL TRIP IN NORTHWESTERN COLORADO	115
W. W. ROBBINS, M.A. Instructor in Biology	
4. MOLLUSCA COLLECTED IN NORTHWESTERN COLORADO IN 1909	125
JUNIUS HENDERSON, B.A. Curator of the Museum	
5. SOME INSECTS COLLECTED IN NORTHWESTERN COLORADO IN 1909	126
T. D. A. COCKERELL Professor of Systematic Zoölogy	
6. REPTILES AND AMPHIBIANS OF THE UNIVERSITY OF COLO- RADO EXPEDITION OF 1909	130
T. D. A. COCKERELL Professor of Systematic Zoölogy	
7. NOTES ON BIRDS AND MAMMALS OF NORTHWESTERN COLO- RADO	132
A. H. FELGER	
8. FOSSIL INVERTEBRATES FROM NORTHWESTERN COLORADO	146
JUNIUS HENDERSON, B.A. Curator of the Museum	
9. FOSSIL PLANTS FROM THE MESA VERDE CRETACEOUS	149
T. D. A. COCKERELL Professor of Systematic Zoölogy	
10. BIBLIOGRAPHY OF PAPERS DEALING WITH THE GEOLOGY AND NATURAL HISTORY OF NORTHWESTERN COLORADO	151

SCIENTIFIC EXPEDITION TO NORTHWESTERN COLORADO IN 1909

	PAGE
1. <i>Itinerary, Topography and Geology</i>	101
JUNIUS HENDERSON	
2. <i>Remarks on the Climatology of Northwestern Colorado</i>	112
W. W. ROBBINS	
3. <i>A Botanical Trip in Northwestern Colorado</i>	115
W. W. ROBBINS	
4. <i>Mollusca Collected in Northwestern Colorado in 1909</i>	125
JUNIUS HENDERSON	
5. <i>Some Insects Collected in Northwestern Colorado in 1909</i>	126
T. D. A. COCKERELL	
6. <i>Reptiles and Amphibians of the University of Colorado Expedition of 1909</i>	130
T. D. A. COCKERELL	
7. <i>Notes on Birds and Mammals of Northwestern Colorado</i>	132
A. H. FELGER	
8. <i>Fossil Invertebrates from Northwestern Colorado</i>	146
JUNIUS HENDERSON	
9. <i>Fossil Plants from the Mesa Verde Cretaceous</i>	149
T. D. A. COCKERELL	
10. <i>Bibliography of Papers Dealing with the Geology and Natural History of Northwestern Colorado</i>	151

ITINERARY, TOPOGRAPHY AND GEOLOGY

BY JUNIUS HENDERSON

The expedition, under the auspices of the University of Colorado Museum, outfitted at Newcastle, Garfield County, and traveled thence by wagon, covering portions of Garfield, Rio Blanco and Routt Counties (Fig. 1). Mr. W. W. Robbins, instructor in biology at the University, had charge of the botanical work. Mr. A. H. Felger, of the Denver North Side High School faculty, acted as ornithologist and mammalogist. James Terry Duce, a student of the Boulder High School, assisted in various lines of work. The writer paid special attention to paleonto-

logical and conchological investigations. Each member of the party to some extent assisted in other lines of work

We desire to express our appreciation of the courtesies received at the hands of the people living along our route, who were almost uniformly kind and assisted us in many ways. Messrs. J. L. Riland, W. A. Kyser, W. B. Blythe and Reuben Ball, of Meeker, were especially helpful to us in securing valuable material for the museum.

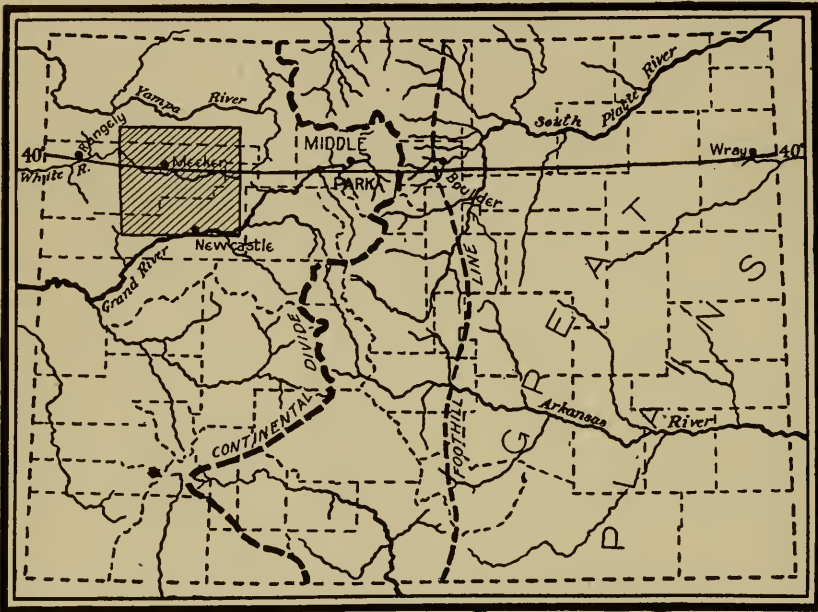


FIG. 1.—Outline map of Colorado, the territory covered by the expedition being enclosed in the square shaded by diagonal lines.

The accompanying map shows the route and localities visited (Fig. 2). Starting on August 3, 1909, we proceeded up Elk Creek, thence to Rifle Gap, where Rifle Creek breaks through the Mesa Verde sandstone ridge, which constitutes the Grand Hogback (Fig. 9). Here we made our first stop. We next passed through the Gap to the Rifle-Meeker stage road, which we followed to Meeker, stopping at Piceance Creek on the way. From Meeker we traveled to Axial and back. Thence

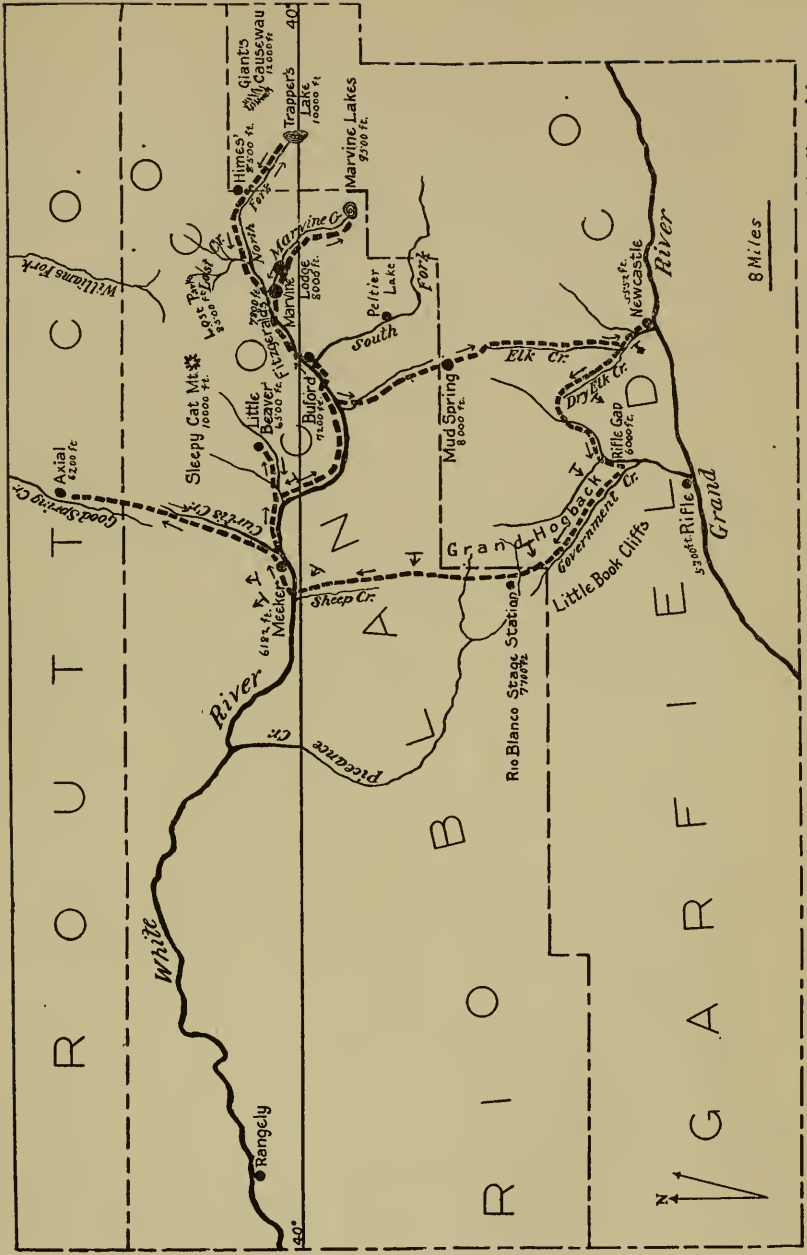


FIG. 2.—Map showing route and localities visited. Route indicated by heavy broken line. Direction of travel indicated by arrows without terminal cross-bars. Direction of dip indicated by conventional dip arrow with terminal cross-bar.

we proceeded to Little Beaver Creek and up White River to Buford, Marvine Lakes and Trapper's Lake, and returned to Newcastle by the Mud Spring road over White River Plateau. The greater part of the distance traveled was over good roads, which gave two horses very little trouble with our heavy load. Where we pulled out of the White River Valley, however, the long, steep, rocky hill, badly washed road and wet weather which then prevailed required a division of the load, with five horses. The roads extend to within five or six miles of Marvine Lakes and Trapper's Lake. We reached Newcastle on the return, September 4.

The following is a list of localities¹ visited and dates:

Newcastle.....	August	1, 2
Newcastle to Rifle Gap.....		3
Rifle Gap.....		4
Rifle Gap to Rio Blanco Stage Station		5
Rio Blanco Stage Station		6
Rio Blanco to Meeker.....		7
Meeker.....		8 to 11
Meeker to Axial.....		12
Axial.....		13
Axial to Meeker.....		14
Meeker.....		15, 16
Meeker to Little Beaver Creek.....		17
Little Beaver Creek.....		18
Little Beaver Creek to Buford.....		19
Buford.....		20 to 23
Buford to Marvine Lodge.....		24
Marvine Lodge to Marvine Lakes and back.....		25
Marvine Lodge.....		26 to 29
Marvine Lodge to Himes'.....		30
Himes' to Trapper's Lake, thence to Fitzgerald's.....		31
Fitzgerald's.....	September	1
Fitzgerald's to Buford.....		2
Buford to near Mud Spring.....		3
Mud Spring to Newcastle.....		4

¹ While we were encamped at Marvine Lodge and Fitzgerald's, August 25 to September 2, Mr. Felger and a guide explored the region adjacent to Marvine Creek and the Lost Park country in search of elk and deer.

The route passed first up a broad valley which separates the escarpment of Mesa Verde sandstones on the one hand from the Dakota sandstone on the other (Fig. 3). The surface débris of the valley conceals the greater part of the Mancos formation, though the lower portion outcrops on the north side (Fig. 8) and the upper part on the south side (Fig. 7). The valley itself results from the erosion of these yielding shales, the bounding ridges being the resistant sandstones of the Mesa Verde and Dakota formations. A very much generalized cross-section

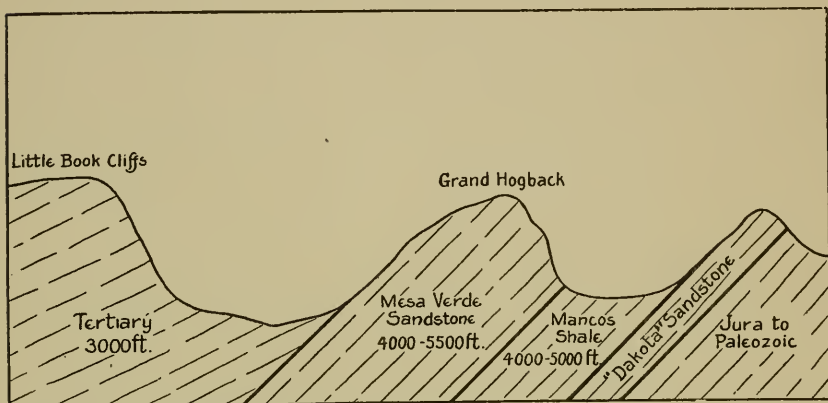


FIG. 3.—Generalized cross-section showing relation of formation to valleys and ridges between Newcastle and Meeker.

of the route to Meeker is shown in Fig. 3. The strata from Newcastle to Rifle Gap dip in a southeasterly direction, giving the ridges a northwesterly strike. Beyond the Gap the dip changes to westerly and consequently the strike of the ridges and bluff lines becomes northerly, thus changing the direction of our route. Throughout the region the directions taken by the valleys and ridges, and hence the roads, are controlled by the direction of the dips of strata.

The passage through Rifle Gap (Fig. 9) carried us out into the Wasatch (Tertiary) formation, with the Little Book Cliffs towering majestically on our left and the Grand Hogback (Mesa Verde formation) on our right (Fig. 3). At Meeker the dip again changes, this time to northwesterly, with corresponding change of strike of bluffs and ridges

to northeasterly. It will be noted that these changes in dip and strike indicate a great anticlinal fold. Long ago the Hayden Survey named the high ridges of Mesa Verde sandstone extending from Grand River to White River the "Grand Hogback," a name which is quite appropriate and still clings to it, though some of the formation names then applied have been superseded by others.

Meeker is in the broad valley of White River. The valley here occupies the Mancos formation, with the Mesa Verde bluffs to the north (Fig. 11) and the Dakota sandstone to the south. On the south side of the valley are several terraces, telling unmistakably of various periods of renewed erosion, as if base level had several times been reached, followed by a renewal of activity from fresh uplift. These terraces were traced far up White River. The lower bottom-lands are extensively irrigated and used as hay lands from Meeker up to within six miles of Trapper's Lake.

The route from Meeker to Axial was chiefly through gulches cut in the Mesa Verde sandstones. From Meeker to Little Beaver Creek, on the other hand, was chiefly in the Mancos. Returning from Little Beaver Creek to the main road and proceeding up White River, we at once broke through the Dakota sandstone into the underlying sandstones, limestones and clays, chiefly of a reddish color, probably mostly representing Jurassic and late Carboniferous time with possibly some Triassic or Permian, though we found no palaeontological evidence of their age. The greater part of the valley is likely in Carboniferous rocks. Marvine Creek is in amygdaloidal basalt, which appears to extend across to Trapper's Lake in a continuous sheet several hundred feet in thickness.

The White River Plateau is the broad, rolling, partly dissected divide which separates the White River canyon from the canyon of the Grand River. It was long ago described¹ as "a lava-capped mesa, irregular and cut by deep canyons and valleys, which often nearly subdivide it . . . with surface irregularly rolling."

The region affords excellent examples of the persistence of perennial streams, as where Rifle Creek at Rifle Gap (Fig. 9) and White River

¹ LADD, STORY B., *Eighth Ann. Rept. U. S. Geol. and Geog. Surv. Terr.*, p. 437.

below Meeker cut through the Mesa Verde escarpment, while the minor drainage by intermittent streams is controlled by the relations of lithological units and the displacement of strata by folds. Thus, with the strata dipping uniformly in a given direction at a given locality, the minor drainage follows yielding strata and produces valleys between more resistant horizons, while the major streams cut through the ridges which have developed from erosion of the lateral valleys, probably continuing in pre-established courses.

The so-called Dakota formation here, as along the foothills of the Front Range, is likely not all of Dakota age. In at least a portion of the region it consists of two sandstone members, with intervening shales. On Little Beaver Creek we found in the top of the upper sandstone fragments of *Ostrea* and *Inoceramus* not specifically determinable but strongly suggesting Benton forms.

The Mancos formation is believed to be equivalent, in point of time of deposition, to the Benton and Niobrara formations and about the lower half of the Pierre. At the base are black calcareous shales, containing thin beds of gray limestone in the upper part, as the Benton does east of the Front Range. Above this series at Newcastle is a limestone in places weathering almost white, containing *Inoceramus* and *Ostrea congesta*, overlaid by calcareous shales. That limestone is not as massive as the basal limestone of the Niobrara east of the Front Range, but otherwise its occurrence and appearance are quite similar. It shows usually on the lower part of the Dakota slope. The greater part of the Mancos throughout the region occupies valleys and is covered by alluvium and débris from the steep valley sides. The top of the formation is frequently found exposed at the base of the Mesa Verde escarpment (Figs 7 and 11). The entire formation is marine, as are the Benton, Niobrara and Pierre equivalents elsewhere. The line of demarcation between this and the next higher formation is not always sufficiently definite to remove its exact position altogether from the realm of personal opinion, although the formations are quite distinct in general character and conditions under which they were deposited.

The Mesa Verde formation consists of alternating massive sandstones, clays and coal beds, and marks a radical change in conditions of

sedimentation. It is believed to include strata representing upper Pierre and most of Fox Hills time.

I am not aware of any Lewis shale or Laramie in the region traversed by us. Neither the overlying Tertiary formation nor those underlying the Dakota were examined particularly by us. Portions of the Wasatch between Rifle Gap and Piceance Creek afford excellent examples of "bad land" topography.

Mr. Richardson¹ says: "In the Grand Hogback, northwest of Newcastle, Colo., T. W. Stanton and H. S. Gale collected fossil plants which F. H. Knowlton refers to the Fort Union, but Gale did not find it practicable to map the rocks containing these fossil leaves distinct from the Wasatch."

The table on the next page (not drawn to scale) shows the relation to each other of the Cretaceous formations of eastern Colorado, the Yampa River Region, and the Grand Hogback near Rifle Gap.

The coal of northeastern Colorado is confined to the Laramie, while in the Yampa Region it is found in both Laramie and Mesa Verde, and in the Grand Hogback it is in the Mesa Verde.

A comparison of the several faunas discussed in a subsequent part of this report, and the associated lithological evidence, is instructive. The Mancos and lowest Mesa Verde faunas are strictly marine. The later Mesa Verde faunas are of brackish-water types. The fossil plants of the Mesa Verde are terrestrial. The evidence as a whole indicates the following post-Dakota geological history of the region:

Throughout Mancos time marine conditions prevailed, with a slowly subsiding sea-floor and low-lying or rather remote shore, so that only fine sediments reached this region. It is likely that deposition was approximately equal to subsidence until several thousand feet of fine lime and clay shales had been deposited. Then the rate of subsidence decreased, or deposition was accelerated, or both, resulting in the shallowing of the sea, the sediments becoming more sandy. Marine conditions, however, still continued until the lower sandstones assigned to Mesa Verde age had been deposited. Then the sea retreated and there followed a period of low-lying shores, swamps and lagoons, with

¹ *U. S. Geol. Surv., Bull.* No. 371, p. 21.

several alternations of land, fresh-water and brackish-water conditions, under which there accumulated a thick series of alternating sandstones, shales, limestones and beds of coal. We did not find the fossil plants

GRAND HOGBACK		YAMPA REGION		NORTH-EASTERN COLORADO
Tertiary (fresh water)	Unconformity cutting out Lewis and Laramie	Tertiary (fresh water)		Tertiary (fresh water)
		Laramie (fresh and brackish water)		Laramie (fresh and brackish water)
		Lewis (marine)		Fox Hills (marine)
Mesa Verde (fresh and brackish water)		Mesa Verde (fresh and brackish water)		Pierre (marine)
Mancos (marine)		Mancos (marine)		Niobrara (marine)
				Benton (marine)
"Dakota"		"Dakota"		"Dakota"

and animals mingled, but each occupies definite and separate strata, showing, at least locally, alternating terrestrial and lagoon conditions. The palms and *Corbicula* indicate a climate considerably milder than

now prevails. At or soon after the close of Mesa Verde time the brackish-water lagoons ceased to exist and the elevation of the region probably began, though it is doubtful whether this occurred until after the period represented in other localities by the Lewis shales and the Laramie formation, for it seems that the absence of the two latter in the Grand Hogback is due to erosion rather than to non-deposition.¹ The post-Mesa Verde elevation of the land likely progressed through Tertiary time and may even continue to the present day. The entire region has been elevated about a mile, or, to speak more precisely, its position has been changed that amount with reference to sea-level, for whether the difference is due entirely to actual elevation with reference to the center of the earth, or partly at least to the tilting of portions of the earth's crust and consequent withdrawal of the ocean into deepening basins, may never be definitely known. The widespread change in the vertical configuration of the continent at and after the close of the Cretaceous was not uniform, but was accompanied by tilting on a large scale, leaving the portion of the continent bordering the Rocky Mountains high above sea-level, while portions of the continent to the east, west and south were but little elevated. The differential movement was particularly pronounced at places along the present borders of the sedimentaries, leaving the strata resting at high angles upon the mountain slopes. The Tertiary beds overlying the Mesa Verde were probably deposited under varying conditions and may be partly subaërial, partly fluvial and partly lacustrine. During and since the deposition of the Tertiary beds rapid erosion has prevailed and numerous canyons have been cut to depths varying from a few hundred to several thousand feet. During Pleistocene time the higher region in the eastern part of the area explored by us was subjected to the action of numerous glaciers, originating at an altitude of from 11,000 to 12,000 feet, uniting and moving down White River Valley to an altitude of 7,500 feet or less, modifying the valley and upon final retreat leaving behind the usual hummocky topography, moraines and lakes. Glacial sinkholes² gave the name "Pothole Valley" to that portion just above Buford.

¹ RICHARDSON, *U. S. Geol. Surv., Bull.* No. 371, p. 18.

² HAYDEN'S *Atlas of Colorado*, etc., sheet v.

The lakes in the upper valleys, as usual in glaciated mountain regions, are of two types—rock basin and morainal—but some at lower levels are “ox-bows” left by the cutting through of river bends. The glacial topography has been since modified but little by erosion in the upper parts of the valleys.

The coal-beds of the Mesa Verde formation are numerous and extensive and aggregate great thickness. The outcrops along the Grand Hogback are easily accessible and have been worked in many places for local consumption, more extensively at Meeker and Newcastle. The coal is now on fire in places near Newcastle, and it seems to have been of frequent occurrence in the past, as much sandstone and clay has been metamorphosed from this cause along the Grand Hogback. Much work has been done upon the geology of this coal-field by the United States Geological Survey, reports of which work are cited in the bibliography accompanying the present report. No coal is found here below the Mesa Verde.

There is much lime and clay in the region, some of which is of economic value, but neither has been much exploited and apparently the best has not usually been selected. Large deposits of gypsum occur in the earlier formations of the upper White River Valley, reminding one forcibly of the Lykins deposits east of the Front Range. Lack of transportation facilities at present prevents any just estimate of its value or future possibilities. Building stone is everywhere abundant, some of it of excellent quality.

Carnotite from Coal Creek, northeast of Meeker, furnished by Mr. J. L. Riland, was tested by Mr. C. J. Marvin by use of sensitized plate, and after an exposure of sixty hours showed very faint radio-activity. The deposits have been described by Gale.¹

Specimens of gilsonite were obtained from J. L. Riland and W. B. Blythe, collected on Piceance Creek, southwest of Meeker, where it is said to occur in considerable quantities. Unexpected difficulties have been encountered, which have prevented complete analyses up to the present writing, but incomplete analyses show that the Riland samples run on an average approximately 77 per cent. carbon and 11.5 per cent.

¹ GALE, HOYT S., *U. S. Geol. Surv. Bull.*, No. 315, pp. 110-17, 1906.

hydrogen, with 9.69 per cent. unaccounted for, which may increase the total amount of carbon somewhat. The Blythe specimens contain about 3 per cent. less of carbon and 1 per cent. more of hydrogen. Some "brown gilsonite" from the same place presented by Mr. Riland is found to be very impure material, containing 15.29 per cent. silica and 7.33 per cent. calcium carbonate.

The agricultural possibilities of the country vastly exceed the present development.

The region traversed ranges from 5,000 to 12,000 feet above sea-level, sloping from the mountains above Trapper's and Marvine Lakes westward, and draining ultimately into the Pacific Ocean.

A partial bibliography appended to this report cites the more important works relating to the region and its biological and geological phenomena. Up to the present time the geology has received much more attention than the biology.

REMARKS ON THE CLIMATOLOGY OF NORTHWESTERN COLORADO

BY W. W. ROBBINS

General account.—As the area visited by the expedition ranges in altitude from 5,000 feet to 12,000 feet, there are, of course, varied climatic conditions. Climatological data are available for Meeker and Rangely.¹ These data represent very accurately climatic conditions existing over the greater part of northwestern Colorado, exclusive of altitudes above 7,000 feet, for which no data are available. Localities below this altitude are dominated by pinyon pine (*Pinus edulis*), Utah cedar (*Sabina utahensis*) sage-brush (*Artemisia tridentata*) and associated plant forms. Even without climatological data, such xerophytic vegetative types as these indicate semi-arid conditions. Western Colorado in general has a semi-arid climate. It belongs to that great arid district which embraces Nevada and Utah.

Precipitation.—Meeker has a mean annual precipitation of 16 inches; Rangely 8.8 inches. This difference is due partially at least to the difference in altitude between the two stations. Meeker is 6,182 feet

¹ *Annual Summary Colorado Section of the Climatological Service.*

and Rangely 5,050 feet above sea-level. The aridity of the climate at Rangely is recognized at once by the record of precipitation. Meeker with a rainfall nearly twice as great must, however, be included with Rangely as arid. This will be apparent by comparison with the climate of Denver. Denver has a mean annual rainfall of but 14 inches as compared with 16 inches at Meeker, and yet the vegetation about Denver

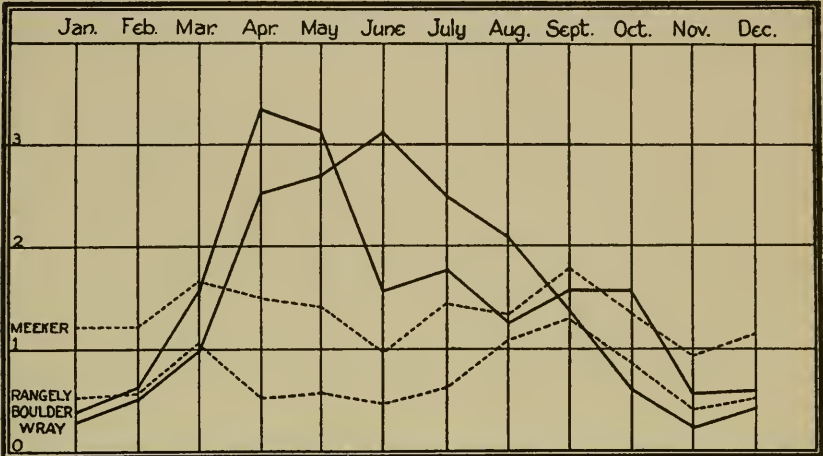


FIG. 4.—Graphic representation of the mean precipitation by months at Meeker, Rangely, Boulder and Wray. The stations, Meeker and Rangely, west of the continental divide, have an even distribution of rainfall throughout the year, as is shown by the flatness of the curves for these stations. On the other hand, Boulder and Wray, stations east of the main range, have the greater percentage of their rainfall during the spring months.

is not as xerophytic in its nature as that about Meeker. This difference is due in large measure to the seasonal distribution of rainfall. At Meeker and Rangely, in fact at all localities west of the continental divide, only about 50 per cent. of total precipitation occurs during the growing season. On the other hand, at Denver, and other stations east of the main range, about 75 per cent. of the yearly precipitation comes during the growing season. Fig. 5 shows graphically the distribution of precipitation throughout the year for stations near the 40th parallel both east and west of the continental divide. Judging from annual precipitation amounts alone leads one into error unless there be a consideration of seasonal distribution

Irrigation is necessary throughout northwestern Colorado for successful farming and fruit-raising

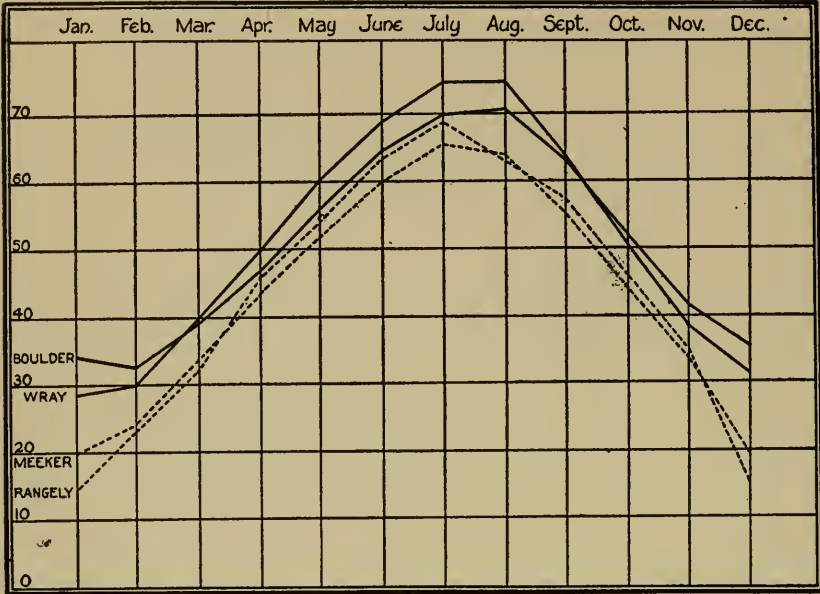


FIG. 5.—Graphic representation of the mean temperature by months at Meeker, Rangely, Boulder and Wray. Meeker and Rangely are west of the continental divide, Boulder and Wray east; all are near the 40th parallel. The greater ranges of temperature will be noted in the cases of Meeker and Rangely.

Temperature.—Northwestern Colorado as a whole has a severe climate. That is, extremes of temperature, both diurnal and annual, are great. Table I gives temperature conditions at four localities in

TABLE I

Station	Altitude in Feet	Mean Annual Temp.*	Warmest Month	Mean Temp. Warmest Month*	Coldest Month	Mean Temp. Coldest Month*	Mean Annual Range*
Boulder.....	5,347	51	Aug.	71	Feb.	33	38
Wray.....	3,512	51	July	74	Jan.	29	45
Meeker.....	6,182	43	July	66	Jan.	20	46
Rangely.....	5,050	43	July	69	Jan.	15	54

* Degrees F.

Colorado, all near the 40th parallel, two on each side of the continental divide. (See Fig. 1 for their relative locations.)

From the table it is seen that the mean annual range of temperature is greater in the case of the two localities, Meeker and Rangely, west of the divide, than it is for Boulder and Wray, stations east of the divide. As a general rule, annual range of temperature decreases with an increase of altitude. Meeker, however, has a greater elevation than Boulder, but a wider range of temperature. The annual march of temperature is given in Fig. 5 for Meeker, Rangely, Boulder and Wray.

The average length of the growing season at Meeker is 95 days; the average date of last killing frost in spring, June 7; and of first killing frost in autumn, September 12. These conditions, together with the severity of the climate, limit horticultural possibilities. Peaches or melons cannot be successfully grown. Some varieties of apples and cherries, however, do well. Hay is a more profitable crop than grain.

A BOTANICAL TRIP IN NORTHWESTERN COLORADO

BY W. W. ROBBINS

For the botanist there is keen pleasure connected with collecting in fields new to him. There is the anticipated enjoyment of getting new species, possibly; of seeing new plant-formations; of making comparisons with the flora and vegetation with which he is familiar. In Colorado there are many new botanical fields. One who has done most of his botanical field-work on plains and in mountains east of the continental divide is always eager to see what is "on the other side of the mountain." It is generally held, and correctly too, that the flora and vegetation west of the continental divide is essentially different from that to the east. These differences will be mentioned at another point.

General account.—The first three weeks of August were spent riding and tramping through a country of stream-cut valleys, some wide and gently sloping at either side, others narrow and abrupt, bounded on both sides by sedimentary ridges. During this time we did not get above an altitude of 7,500 feet, and hence through it all there was a sameness and monotony to the vegetation. The general character of

this was xerophytic. Rocky ridges with scattered pinyon pines and cedars; stream benches, level areas, roadsides, gradual slopes and mesas covered with sage-brush; scrub oak at the bases of slopes; stream-sides fringed with cottonwoods; a dearth of blooming herbs—such was the general appearance of the country.

After three weeks of sage-brush and stony ridges an aspen grove was a relief. It was an indication of moister and cooler climatic conditions and a greater variety of plant species. Aspens become abundant at 7,000 feet altitude. A very few Rocky Mountain yellow pines (rock

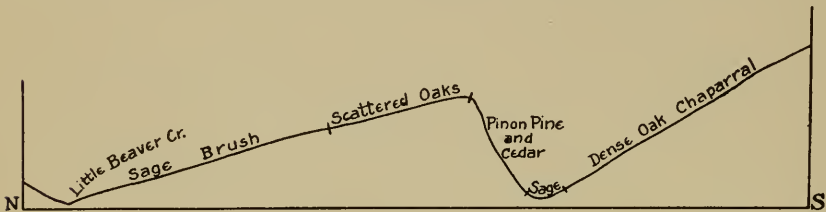


FIG. 6.—Generalized N-S cross-section in vicinity of Little Beaver Creek. Sage-brush covers the lower portions of the long, gradual slope from Little Beaver Creek. As the soil becomes more shallow at the upper part of the slope, sage is replaced by scattered clumps of oak. Pinyon pine and cedars occupy the steep, rocky south exposure. The north slope covered with dense oak chaparral is steeper than the slope from Little Beaver Creek, and hence sage-brush is confined to a narrow strip along the stream.

pinus) are scattered among them. At this elevation Douglas and blue spruce occur in moist, shaded gulches. At about 8,000 feet altitude lodgepole pine appears in abundant numbers, and at about 10,000 feet Engelmann spruce forms the dominant tree growth, extending up to timberline. Aspen is far more abundant in northwestern Colorado than at similar altitudes on the eastern slope. It is usually much larger also, often reaching a diameter of two or more feet and with bark at the base of the trunk corrugated.

The greater time of the expedition was spent at altitudes below 7,500 feet. Furthermore, in making comparisons between the flora and vegetation east and west of the continental divide, the differences are particularly marked at the lower altitudes. For the above reasons this account will be restricted for the most part to a discussion of conditions existing below an altitude of 7,500 feet.

Vegetation of streamside and bottom-lands.—From a ridge crest the courses of the Grand and White rivers may be followed for miles by the presence of cottonwoods which fringe them on both sides (Fig. 11). The narrowleaf cottonwood is the dominant tree along the largest streams. The western cottonwood (*Populus sargentii*) and the lanceleaf cottonwood were not seen. Only one tree of Wislizenus' cottonwood was seen and that along Dry Elk Creek between Rifle Gap and Rio Blanco Stage Station. This species is southern in its distribution, but extends to higher latitudes west of the continental divide than east. Narrowleaf cottonwoods were quite commonly overgrown with clematis in bloom. Streamside birch, alder, choke-cherry, skunk-bush, willows and thorn-apples form an undergrowth of shrubs along the streams. Buffalo berry, a small thorny tree with silvery leaves and bright red berries, grows in clumps in moist river bottoms. It also occurs along fences of irrigated fields. Abundant and conspicuous herbaceous plants of streamside and bottom-lands are *Rudbeckia ampla*, *Lactuca pulchella*, *Helianthus nuttalli*, *Solidago canadensis*, *Aster adscendens* and *Gymnolomia multiflora*. Hops climb and trail among the shrubbery. It is noticed that the conspicuous flowering plants of streamside and bottom-lands are composites. This is the case in all situations. The lower altitudes throughout Colorado have a late summer and autumn vegetation which is characterized by the blooming of composites.

COLLECTION OF PLANTS FROM STREAMSIDE AND BOTTOM-LANDS¹

<i>Typha latifolia</i> L.	<i>Carex utriculata</i> Boott.
<i>Equisetum laevigatum</i> R. Br.	<i>Eleocharis palustris</i> (L.) R. & S.
<i>Equisetum pratense</i> Ehrh.	<i>Scirpus lacustris</i> L.
<i>Triglochin palustris</i> L. (half-submersed)	<i>Lemna minor</i> L. (floating)
<i>Beckmannia erucaeformis</i> (L.) Host.	<i>Juncus bufonius</i> L.
<i>Chaetochloa viridis</i> (L.) Scribn.	<i>Juncus nodosus</i> L.
<i>Alopecurus aristulatus</i> Michx.	<i>Vagnera stellata</i> L.
<i>Deschampsia caespitosa</i> (L.) Beauv.	<i>Populus angustifolia</i> James
<i>Elymus canadensis</i> L.	<i>Salix</i> spp.
<i>Elymus condensatus</i> Presl.	<i>Alnus tenuifolia</i> Nutt.
<i>Hordeum jubatum</i> L.	<i>Betula fontinalis</i> Sarg.

¹ The writer is under obligation to Professor Aven Nelson, of the University of Wyoming, who kindly determined most of the specimens in this and succeeding lists.

- Quercus utahensis* (DC.) Rydb.
Humulus lupulus neo-mexicanus Nels. and Ckll.
Chenopodium berlandieri Moq.
Vaccaria vaccaria (L.) Britton
Batrachium flaccidum (Pers.) Rupr. (half-submersed)
Clematis ligusticifolia Nutt.
Halerpestes cymbalaria (Pursh) Greene
Ranunculus eremogenes Greene
Ranunculus macounii Britton
Ranunculus reptans L.
Arabis oxyphylla Greene
Roripa nasturtium (L.) Rusby
Roripa sinuata (Nutt.) A. S. Hitch.
Sophia incisa (Engelm.) Greene
Peritoma serrulatum (Pursh) DC. (*Cleome serrulata* Pursh)
Ribes longiflorum Nutt.
Geum strictum Ait.
Crataegus saligna Greene
Crataegus rivularis Nutt.
Prunus melanocarpa (A. Nels.) Rydb.
Astragalus canadensis Muhl.
Astragalus pattersonii Gray
Glycyrrhiza lepidota Nutt.
Melilotus alba Desv.
Vicia americana Muhl.
Rhus trilobata Nutt.
Acer interior Britton
Sidalcea candida A. Gray
Sidalcea neo-mexicana A. Gray
Lepargyrea argentea (Nutt.) Greene
Epilobium adenocaulon Hausskn.
Epilobium paniculatum Nutt.
Onogra strigosa Rydb.
- Hippuris vulgaris* L.
Sida stolonifera riparia Rydb.
Cicuta occidentalis Greene
Sium cicutaefolium Gmelin
Apocynum ambigens Greene
Lappula floribunda (Lehm.) Greene
Mentha borealis Michx.
Monarda menthaefolia Benth.
Stachys palustris L.
Castilleja sulphurea Rydb.
Mimulus hallii Greene (half-submersed)
Veronica americana Schwein.
Veronica anagallis-aquatica L.
Galium asperrimum Gray
Lonicera involucrata Banks
Symphoricarpos occidentalis Hook.
Valeriana ceratophylla Hook.
Troximon aurantiacum Hook.
Achillaea lanulosa Nutt.
Artemisia aromatica A. Nels.
Aster adscendens Lindl.
Aster hebecladus DC.
Aster laetivirens Greene
Erigeron divergens T. & G.
Erigeron ramosus (Walt.) B. S. P.
Grindelia squarrosa (Pursh) Dunal
Gymnolomia multiflora (Nutt.) B. & H.
Helianthus nuttallii T. & G.
Leptilon canadensis (L.) Britton
Madia glomerata Hook.
Rudbeckia ampla A. Nels.
Rudbeckia laciniata L.
Solidago canadensis L.
Solidago elongata L.
Lactuca pulchella (Pursh) DC.
Sonchus asper (L.) All.

Intermittent streams.—There are many intermittent streams in the area covered. They usually occupy narrow, deep beds which have a considerable grade. In August, when the region was visited, most of these streams were completely dry and one was able to walk in the bottom of the stream-bed. In some cases this was of soft shale, in other cases of solid rock. Since there is flowing water only during times of storms, there is no typical streamside vegetation. A sickly cottonwood

may be seen occasionally. *Quercus gunnisonii*, *Amelanchier oreophila* and *Rhus trilobata* are usually abundant, sometimes growing even within the stream-bed. The roots of these shrubs are often exposed along the eroded sides of the bank. Flood plains of the intermittent streams consist of soil rich in alkali and are usually covered with greasewood (*Sarcobatus vermiculatus*).

Vegetation of streamside and gulch.—At an altitude of 7,000 feet, the streamside vegetation differs considerably from that at lower elevations. This is due partly to the direct effect of climatic differences which accompany a change of altitude, but in great measure to differences of stream topography. At lower elevations there are large, meandering streams flowing in wide valleys, which give an abundance of bottom-lands with a deep and fine-grained soil. In the lower foothills, on the other hand, there are many small streams; these, as well as the large ones, flow in narrow and steep-sided gulches. Thus in addition to streamside moisture, exposure must be considered as an important factor. Moist, shaded slopes and gulches have their characteristic forms of plant life. Hence in the lower foothills we shall speak of streamside and gulch vegetation rather than of streamside and bottom-land vegetation. In the following list particular notice should be called to such typical gulch forms as *Populus tremuloides*, *Pseudotsuga mucronata*, *Vagnera stellata*, *Sidalcea candida*, *Sidalcea neo-mexicana*, *Geranium richardsonii*, *Acer glabrum*, *Angelica ampla*, *Lonicera involucrata* and *Actaea viridiflora*. The two species of *Sidalcea* occur in great abundance and are invariably found growing together.

COLLECTION OF STREAMSIDE AND GULCH PLANTS

<i>Equisetum arvense</i> L.	<i>Populus tremuloides</i> Michx.
<i>Picea parryana</i> (Andree) Sarg.	<i>Salix</i> spp.
<i>Pseudotsuga mucronata</i> (Raf.) Sudw.	<i>Alnus tenuifolia</i> Nutt.
<i>Elymus condensatus</i> Presl.	<i>Betula fontinalis</i> Sarg.
<i>Hordeum nodosum</i> L.	<i>Quercus gunnisonii</i> (Torr.) Rydb.
<i>Scirpus lacustris</i> L.	<i>Urtica gracilis</i> Ait.
<i>Juncus saximontanus</i> A. Nels.	<i>Eriogonum campanulatum</i> Nutt.
<i>Allium cernuum</i> Roth.	<i>Eriogonum umbellatum</i> Torr.
<i>Vagnera amplexicaulis</i> (Nutt.) Morong	<i>Eriogonum umbelliferum</i> Small
<i>Iris missouriensis</i> Nutt.	<i>Polygonum spergulariaeforme</i> Meis. (?)
<i>Populus angustifolia</i> James	<i>Rumex occidentalis</i> Wats.

- Aconitum insigne* Greene
Actaea viridiflora Greene
Halerpestes cymbalaria (Pursh) Greene
Ranunculus macounii Britton
Thalictrum fendleri Engelm.
Arabis drummondii Gray
Arabis oxyphylla Greene
Lepidium crandallii Rydb.
Sophia incisa (Engelm.) Greene
Stanleya arcuata Rydb.
Thelypodium gracilipes (A. Gray) S. Wats.
Capnoides aureum (Willd.) Kuntze
Ribes pumilum Nutt.
Cercocarpus parvifolius Nutt.
Geum strictum Ait.
Potentilla diversifolia Lehm.
Rosa nutkana Presl.
Amelanchier oreophila A. Nels.
Crataegus saligna Greene
Crataegus cernis A. Nels.
Prunus melanocarpa (A. Nels.) Rydb.
Prunus pennsylvanica L. f.
Vicia americana Muhl.
Geranium fremontii A. Gray
Geranium richardsonii Fish. & Traut.
Rhus trilobata (Nutt.) Small
Acer glabrum Torr.
Vitis vulpina L.
Sidalcea candida A. Gray
Sidalcea neo-mexicana A. Gray
- Malvastrum coccineum* (Pursh) A. Gray
Chamaenerion angustifolium (L.) Scop
Epilobium adenocaulon Hasskn.
Epilobium paniculatum Nutt.
Gayophytum ramosissimum T. & G.
Onogra strigosa Rydb.
Angelica ampla A. Nels.
Cicuta occidentalis Greene
Washingtonia obtusa C. & R.
Vaccinium oreophila Rydb.
Androsace subulifera (A. Gray) Rydb.
Asclepias speciosa Torr.
Gilia aggregata (Pursh) Spreng.
Polemonium joliasissimum A. Gray
Phacelia glandulosa Nutt.
Agastache urticifolia (Benth.) Kuntze
Mentha penardi (Brig.) Rydb.
Castilleja linariaefolia Benth.
Orthocarpus luteus Nutt.
Pentstemon strictus Benth.
Pentstemon unilateralis Rydb.
Galium asperrimum Gray
Lonicera involucrata Banks.
Symphoricarpos pauciflorus (Robbins) Britton
Gymnolomia multiflora (Nutt.) B. & H.
Pyrocoma crocea (Gray) Greene
Rudbeckia laciniata L.
Senecio admirabilis Greene
Solidago canadensis L.

Sage-brush formation.¹—One who passes from the eastern to the western slope of the Rocky Mountains in Colorado cannot fail to be struck with the great difference between the vegetation of the great plains and of level areas in the western part of the state. The plains of eastern Colorado are grass-covered; sage-brush is dominant on level stretches of western Colorado. This sage (*Artemisia tridentata*) is most abundant on flat expanses back from streams; it occurs on flat areas generally, reaching its greatest development in deep, fine-grained soil. As slopes become steeper and more stony, with a consequent decrease in soil depth, sage-brush gives away to pinyon pine, cedar and shrubs

¹ POOL, R. J., "Histological Studies in the Artemesia Formation," *Univ. of Neb. Stud.*, Vol. VIII, pp. 1-28, Oct., 1908.

typical of rocky slopes. On north slopes sage-brush often grades into scrub oak (Fig. 6). The sage-brush formation forms a pure, close, regular stand. In any sage-plain the shrubs are of uniform height, commonly three or four feet (Fig. 8). Along roadsides and in more favorable situations, however, individual plants may reach a height of six to eight feet.

Rabbit-brush (*Chrysothamnus* sp.) is the common associate of sage-brush. It occupies moister soil, being found nearer to streams and in places where seepage exists. Looking over a sage-plain, the silvery-gray sage-brush is readily distinguished from the greener rabbit-brush. Grease-wood alternates with sage-brush in alkaline soil.

It is not uncommon to find low, rounded hills covered with large patches of vegetation which give them a yellowish hue. This color is due to an association of *Chrysothamnus glaucus*, *Eriogonum campanulatum* and *Gutierrezia sarothrae*, all with yellow bloom. This association is a common one of the sage-brush formation.

Sage-brush has a great altitudinal range and will grow under a variety of edaphic conditions. As has been said, it is best developed below 6,000 feet altitude over flat areas, having rather deep, fine-grained soil. It is by no means absent, however, from steep slopes; it often forms there the undergrowth below pinyon pine and cedar. Sage-brush decreases in abundance with altitude, but occurs at times as high as 10,000 feet. At high altitudes it is confined to warm, exposed ridge crests.

Sage-brush alternates with oak chaparral on north and south slopes. The north exposure may be clothed with oak shrubbery while the south exposure bears sage-brush, the two formations meeting at the bottom of the gulch.

In northwestern Colorado, the present farming land occupies, almost without exception, areas which were covered with sage-brush. This has been removed by "grubbing."

COLLECTION OF PLANTS FROM SAGE-BRUSH FORMATION

Atriplex confertifolia S. Wats.
Erigeron campanulatum Nutt.
Grayia brandegei Gray

Salsola tragus L.
Sarcobatus vermiculatus (Hook.) Torr.
Astragalus haydenianus Gray

<i>Hedysarum carnosulum</i> Greene	<i>Artemisia frigida</i> Willd.
<i>Lupinus flexuosus</i> Lindl.	<i>Carduus tracyi</i> Rydb.
<i>Lupinus greenei</i> A. Nels.	<i>Chrysoopsis villosa</i> Nutt.
<i>Anogra coronopifolia</i> (T. & G.) Britton	<i>Chrysothamnus affinus</i> A. Nels.
<i>Asclepias speciosa</i> Torr.	<i>Chrysothamnus glaucus</i> A. Nels.
<i>Orthocarpus luteus</i> Nutt.	<i>Grindelia squarrosa</i> (Pursh) Dunal

Vegetation of ridges.—Below an altitude of 7,000 feet the ridges are of sedimentary rock, mostly Mesa Verde and Dakota sandstone. The soil is shallow, sandy and rocky except where large exposures of Mancos shale are disintegrating. In many places the strata of the hillsides are exposed and the only soil occupies rock crevices. The tree growth of ridges consists of pinyon pine and Utah cedar (Fig. 11). These two species are always associated. In the vicinity of Newcastle (altitude 5,562 feet) cedar forms probably 90 per cent. of the tree growth, pinyon pine being relatively less abundant. At higher altitudes, however, pinyon pine increases in abundance relative to cedar. At the upper altitudinal limit of the pinyon-cedar zone, pinyon pine, not cedar, extends higher.

These two species are particularly adapted to withstand severe climatic conditions. From the account of climatology it may be seen that the annual ranges of temperature in western Colorado are wide. Diurnal ranges of temperature are also wide there and especially on stony ridges where pinyon pine and cedar grow. These two trees grow in an open stand, occupying a sandy, stony soil and are seldom fifteen feet high.¹

The common shrubs of ridges are *Cercocarpus parvifolius*, *Amelanchier* spp., *Symphoricarpos* spp., *Peraphyllum ramosissimum*, *Fendlera rupicola* and *Atriplex canescens*. Sage-brush and rabbit-brush are scattered. *Ephedra antisyphilitica*, the joint-fir, was found associated with pinyon pine and cedar in the vicinity of Newcastle, but at no point farther north. This peculiar shrub is more at home in southern Colorado, New Mexico and Arizona. Its occurrence at Newcastle is a high-latitude record.

At this season of the year, the herbaceous vegetation of ridges is sparse, as will be seen from the following list.

¹ PHILLIPS, F. J., "A Study of Pinyon Pine," *Bot. Gaz.*, Vol. XLVIII, pp. 216-23, September, 1909.

COLLECTION OF PLANTS FROM RIDGES

<i>Pinus edulis</i> Engelm.	<i>Amelanchier rubescens</i> Greene ?
<i>Sabina utahensis</i> (Engelm.) Rydb.	<i>Peraphyllum ramosissimum</i> Nutt.
<i>Ephedra antisylphitica</i> E. A. Mey.	<i>Lupinus greenei</i> A. Nels.
<i>Eriocoma cuspidata</i> Nutt.	<i>Touitorea speciosa</i> Osterh.
<i>Hordeum jubatum</i> L.	<i>Asclepiodora decumbens</i> (Nutt.) A. Gray
<i>Sitanion pubiflorum</i> J. G. Smith	<i>Gilia aggregata</i> (Pursh) Spreng.
<i>Quercus gunnisonii</i> (Torr.) Rydb.	<i>Castilleja flava</i> Wats.
<i>Quercus utahensis</i> (DC.) Rydb.	<i>Symphoricarpos occidentalis</i> Hook.
<i>Eriogonum alatum</i> Torr.	<i>Artemisia tridentata</i> Nutt.
<i>Eriogonum tristichum</i> Small	<i>Artemisia wrightii</i> Gray
<i>Atriplex canescens</i> (Pursh) James	<i>Aster nelsonii</i> Greene
<i>Atriplex confertifolia</i> (Torr.) Wats.	<i>Brickellia microphylla</i> Gray
<i>Odotemon aquifolium</i> (Pursh) Rydb.	<i>Carduus undulatus</i> Nutt.
<i>Ribes vallicola</i> Greene	<i>Chrysothamnus arida</i> A. Nels.
<i>Fendlera rupicola</i> Engelm. & Gray	<i>Chrysothamnus graveolens</i> (Nutt.) Greene
<i>Cercocarpus parvifolius</i> Nutt.	<i>Coleosanthus albicaulis</i> Rydb.
<i>Kunzia tridentata</i> (Pursh) Spreng.	<i>Petrodora pumila</i> (T. & G.) Greene
<i>Amelanchier oreophila</i> A. Nels.	<i>Solidago trinervata</i> Greene

Oak chaparral.—In northwestern Colorado this formation is a thicket of *Quercus utahensis* and *Q. gunnisonii*. These two species seldom grow higher than ten or twelve feet. At lower altitudes oak chaparral forms the transition formation between sage-plain and ridge. Here it usually extends as a fringe along the base of the slope (see Fig. 10). In passing from Newcastle (5,562 ft.) up to 7,000 feet elevation, oak increases in abundance, often covering whole hillsides at the higher elevations. From Rifle Gap to Rio Blanco Stage Station, the Little Book Cliffs are in constant view on the left. With increasing altitude the appearance of these cliffs changes from a duller to a greener hue, due to the greater abundance of oak chaparral. Intermixed with the oak are bushes of mountain mahogany, which at this time of year are in fruit, and the long plumose styles give them from a distance a silvery color, standing out in pleasing contrast to the green mass of oak.

Vegetation of Mancos shale.—Hills of Mancos shale are very destitute of vegetation (Fig. 8). This shale is easily weathered, and on steep slopes most of the vegetation that may get started is washed away. *Cercocarpus parvifolius* and *Amelanchier rubescens* are the common shrubs scattered here and there on the almost totally bare slopes. *Erio-*

gonum tristichum is a successful herb of the shale slopes. Level areas of shale soil are grown over with sage-brush.

Ruderals.—The most common ruderal is sage-brush. With rabbit-brush it forms the common roadside vegetation (Fig. 7). Russian thistle is far less abundant than on the eastern plains. The following is a list of some of the common ruderals:

Chenopodium berlandieri Moq.

Salsola tragus L.

Vaccaria vaccaria (L.) Britton

Peritoma inornatum Greene

Peritoma serrulatum (Pursh) DC.

Melilotus alba Desv.

Melilotus officinalis (L.) Lam.

Orthocarpus luteus Nutt.

Marrubium vulgare L.

Aster hebecladus DC.

Grindelia squarrosa (Pursh) Dunal

A comparison of conditions east and west of the continental divide.¹

—The general differences between the vegetation east and west of the continental divide are very striking. These dissimilarities are more marked in northern than in southern Colorado and at lower than at higher altitudes. Comparisons may be made of climatic and vegetative conditions at Rangely and Wray and at Boulder and Meeker. These four stations all being near the 40th parallel, any effect of altitude is eliminated (see map, Fig. 1, for relative locations).

	Wray	Rangely
Relation to divide.....	East	West
Altitude.....	3,512 feet	5,050 feet
Mean annual precipitation.....	17.18 inches	8.84 inches
Percentage during growing season.....	80	55
Mean annual temperature.....	51 F.	43 F.
Mean summer temperature.....	72 F.	62 F.
Mean annual range.....	45 F.	54 F.

At Wray the vegetation is a grassland formation. This consists for the most part of various bunch-grasses, of grama grass (*Bouteloua oligostachya*), and buffalo grass (*Bulbilis dactyloides*) At Rangely,

¹ GRAY, ASA, AND HOOKER, JOSEPH D., "The Vegetation of the Rocky Mountain Region and a Comparison with That of Other Parts of the World," *Bull. U. S. Geol. and Geog. Surv. of Territories*, Vol. VI, No. 1, pp. 1-62, 1880.

sage-brush is the characteristic form of vegetation; large grass-covered areas are totally absent, and grama and buffalo grasses do not occur.

	Boulder	Meeker
Relation to divide.....	East	West
Altitude.....	5,347 feet	6,182 feet
Mean annual precipitation.....	18.27 inches	16.37 inches
Percentage during growing season.....	69	53
Mean annual temperature.....	51 F.	43 F.
Mean summer temperature.....	69 F.	64 F.
Mean annual range.....	38 F.	46 F.

The vicinity of Boulder is the meeting-ground of grassland and Rocky Mountain yellow pine (rock pine) formations; *Yucca glauca* is abundant. There are no oaks, pinyon pines or Utah cedars. At Meeker, sage-brush is dominant over level areas, pinyon pines and cedars on the ridges, and oak along the bases of slopes. There is no Rocky Mountain yellow pine or *Yucca glauca*, and large grassland areas are totally absent.

Southern forms have extended farther north in western Colorado than in eastern. Examples of these are *Quercus* spp., *Ephedra anti-syphilitica* and *Populus wislizeni*. The climate of northwestern Colorado is drier from the vegetation standpoint than that of eastern Colorado at the same latitude and altitude, hence southern forms find, on the drier western slope, conditions more nearly like those to which they are accustomed in the hot, arid districts of Arizona and New Mexico.

MOLLUSCA COLLECTED IN NORTHWESTERN COLORADO IN 1909

BY JUNIUS HENDERSON

An interesting molluscan fauna was obtained. As a supplement to *The Mollusca of Colorado* is contemplated in the near future which will discuss somewhat fully this fauna, it is thought best at present to give only a list of species collected, as follows:

<i>Pisidium</i> sp.	<i>Thysanophora ingersolli</i> Bland
<i>Oreohelix cooperi</i> W. G. B.	<i>Pupilla blandi</i> Morse
<i>Oreohelix haydeni gabbiana</i> Hemph.	<i>Vertigo concinnula</i> Ckll.

<i>Vertigo milium</i> Gld.	<i>Succinea avara</i> Say
<i>Vallonia cyclophorella</i> Anc.	<i>Lymnaea palustris</i> Müll.
<i>Vitrea rhoadsi</i> Pils.	<i>Lymnaea caeperata</i> Say
<i>Vitrea alaskana</i> Dall	<i>Planorbis trivolvis</i> Say
<i>Euconulus trochiformis</i> Montagu	<i>Planorbis parvus</i> Say
<i>Zonitoides arboreus</i> Say	<i>Physa</i> spp.
<i>Agriolimax campestris</i> Binn.	<i>Aplexa hypnorum</i> Linn.
<i>Pyramidula cronkhitei anthonyi</i> Pils.	<i>Valvata lewisi</i> Currier
<i>Succinea haydeni</i> W. G. B.	

SOME INSECTS COLLECTED IN NORTHWESTERN COLORADO IN 1909

BY T. D. A. COCKERELL

The insects recorded in this paper were obtained by the University of Colorado Expedition in 1909 under Professor Junius Henderson. Collectors' names are abbreviated as follows: H.=J. Henderson, R.=W. W. Robbins, D.=Terry Duce.

LEPIDOPTERA RHOPALOCERA

Danaus plexippus (L.) var. a. Inner spots of apical patch of anterior wings large and fulvous. Newcastle, August 2 (R.).

Basilarchia misippus (L.) var. a. Entirely *misippus*, but showing a slight tendency toward *B. hultii* in the better-developed submarginal white spots, and the presence of five fulvous patches in the black apical area of anterior wings. Newcastle, August 3 (R.).

B. weidemeyeri (Edw.) var. a. Female; white band on under side of hind wings rather narrow, the costal white patch no larger than the others; basal area (before the band) larger; orange lunules on hind wing beneath dull, and pallid basally. Meeker August 8 (D.).

Argynnis leto charlottii (Barnes). Newcastle (R.). This is a good subspecies of *A. leto*; the yellow border on hind wings beneath (female) is much broader. I do not quite understand the name; was it after one Charlotte, and if so why has it a masculine termination? Genuine *A. leto* occurs only westward of Colorado.

Satyrus charon (Edw.). Fitzgerald's, September 2 (D.).

S. alope olympus (Edw.). Meeker, August 9; Newcastle, August 2, "Common" (both R.).

Pieris beckerii (Edw.). Buford, August 21 (H.). I have specimens of this which I collected at San Pedro and La Jolla, California, but in spite of the very different environment, it is impossible to separate the Colorado insect even as a race. Mr. Nash took *P. beckerii* years ago at Poncha Pass, Colorado.

P. rapæ L. Buford, August 21 (D.). This is a species of Europe, introduced.

P. occidentalis Reakirt. Newcastle, August 2 (R.).

P. napi cruciferarum (Boisduval). Newcastle, August 2 (R.). Meeker, August 9 (R.); Buford, August 21 (D.).

Eurymus eurytheme eriphyle (Edw.). Rifle Gap, August 4 (R.); Buford, August 23 (D.).

Hesperia tessellata Scudder. Newcastle, August 8 (R.).

LEPIDOPTERA HETEROCERA

Smerinthus jamaicensis geminatus (Say). Meeker, August 9 (R.). This is apparently the most western record for this species, which is characteristic of the Atlantic and middle states. Good specimens have been taken at Boulder by Mr. G. Hite.

Apantesis parthenice intermedia (Stretch). Rio Blanco, August 5 (R.). Hampson's table, at the point where separation is made on the color of the abdomen beneath, is unsatisfactory. The present specimen has the abdomen with a pair of large quadrate black patches on each segment.

Holomelina immaculata (Reakirt). Newcastle, August 2 (R.).

Schinia acutilinea separata (Grote). Meeker, August 9 (R.). This is a true *separata*, but the subterminal line is strongly sinuous, in the manner of *acutilinea*. Dr. J. B. Smith's opinion that the two are forms of one species appears to be correct. The common *Schinia* at Boulder is *S. cumatilis* Grote.

HEMIPTERA HETEROPTERA

Phymata erosa fasciata (Gray). On *Solidago*, Newcastle, August 8 (R.).

Lygæus reclinatus Say. Newcastle, August 1 (R.).

Lygus pratensis (L.). On *Solidago*, ten miles east of Meeker, August 19 (R.).

Alydus scutellatus Van Duzee. Buford, August 23 (D.). I had taken this for a variety of *A. conspersus* Montandon (which is common on the university campus at Boulder), but it certainly differs by the unspotted but marbled membrane, the nervures anastomosing, and by the more slender hind femora with a pallid subapical annulus. The scutellum is deep velvet-black, with the extreme apex white. The membrane, however, is pale between the veins, and a considerable part of the underside of the abdomen is pallid, spotted with black and speckled with red. The type locality of *scutellatus* is Beulah, New Mexico. The Buford insect is certainly *scutellatus* rather than *conspersus*, but perhaps a distinct variety.

HEMIPTERA HOMOPTERA

Ceresa basalis Walker. Buford, August 23 (D.). The common *Ceresa* at Boulder is *C. bubalus* (Fabr.).

HYMENOPTERA APOIDEA (BEES)

Apis mellifera ligustica (Spinola). Meeker, August 8 (D.); Rifle Gap, August 4 at "bee plant" (R.).

Bombus huntii Greene. Newcastle, August 2 and 3, at *Cleome* or "bee plant" (R.); Meeker, August 9, at *Cleome serrulata* (R.); ten miles east of Meeker, August 19, at *Solidago* (R.); $2\frac{3}{4}$ miles south of Axial, August 13, a male at *Rudbeckia ampla* (R.).

B. centralis Cresson. This is exactly like *justus* Cress., in nearly all respects, but the worker (female not seen by me) has black hair on the middle of the basal part of the abdomen. Mr. Franklin (in litt.) states that *centralis* is "a freak specimen" of *justus*, and as the name has priority, uses it for all *justus*. Five workers before me all agree with Cresson's description of *centralis*, and seem to represent a valid geographical race, which must extend (at lower altitudes than *B. flavifrons*) from California to western Colorado. Meeker, August 9, males and workers at *Cleome serrulata* (R.); Newcastle, August 3, at *Cleome* (R.); Rifle Gap, August 4, at "bee plant" (R.).

B. nevadensis Cresson. $2\frac{3}{4}$ miles south of Axial, August 13, a male at *Achillea* (R.).

B. appositus Cresson. Newcastle, August 2, male at *Carduus* (R.).

B. fervidus (Fabricius). Rifle Gap, August 4, at *Helianthus* and at "bee plant" (R.); Meeker, August 9, male at *Cleome serrulata* (R.). One of the Rifle Gap specimens (worker) has the thoracic band very poorly developed.

B. occidentalis howardii (Cresson). Ten miles east of Meeker, August 19, males at *Solidago* (R.). The hair on the apical segments of the abdomen varies from whitish to pale reddish.

Melissodes agilis Cresson. Rifle Gap, August 4, at *Helianthus* (R.). The specimen is a male, peculiar for its rather large size (about 12 mm. long), labrum black with a large whitish spot, mandibles without light spots at base, face unusually broad, flagellum very slender and pale, apical plate of abdomen with the notches very near the end. I had some thought of treating it as a distinct species or subspecies; but it is in other respects so distinctly *agilis*, and that species is so variable, that segregation does not seem justifiable. The slender pale flagellum associates it with *agilis* rather than with *menuacha*.

M. mysops Ckll. $2\frac{3}{4}$ miles south of Axial, August 13, at flowers of *Rudbeckia ampla*, one female (R.).

Megachile sexdentata Rob. Rifle Gap, August 3, male and female at *Helianthus* (R.). The male is the insect which passes in Colorado and New Mexico for *M. pruina* Smith. *M. sexdentata* differs in certain respects from *pruina*, but is at least very closely allied.

M. cleomis Ckll. Meeker, August 9, at *Cleome serrulata*, one male (R.).

M. pugnata Say. Ten miles east of Meeker, August 19, at *Solidago*, one male (R.). The specimen is unquestionably *pugnata*, but the hair of the mesothorax above is wholly pale, and the first recurrent nervure meets the first transverso-cubital. The change in the venation is especially interesting, as ordinarily it would be considered a good specific character.

Osmia mandibularis Cresson; variety like that known from Rociada, New Mexico. Newcastle, August 3, at flowers of *Carduus* (R.).

Perdita albipennis Cresson. Rifle Gap, August 4, male at flowers of *Helianthus* (R.).

Halictus armaticeps Cresson. Rifle Gap, August 4, at flowers of *Helianthus* (R.).

HYMENOPTERA VESPOIDEA AND SPHECOIDEA (Wasps)

These have all been determined by Mr. S. A. Rohwer.

Vespa maculata L. Buford, August 21 (H.), and 23 (D.).

V. arenaria Fabr. Buford, August 22 (H.).

V. communis Sauss. Seven miles below Marvine Lake, Rio Blanco Co., August 26 (H.), Marvine Lodge, August 28 (D.).

Polistes sp. Newcastle, August 2 (R.). Mr. Rohwer says that this is identical with a form which he collected at Rifle, Colorado, and is perhaps a variety of *P. variatus* Cresson. More material is needed to determine its exact status.

Eumenes coloradensis Cresson. "A variety with a small lateral spot on the side of the first abdominal segment" (Rohwer). Meeker, August 9 (R.).

Chlorion (Proterospheæ) ichneumoneum (L.). Newcastle, August 2 (R.). "The abdomen is a little blacker than in Boulder specimens" (Rohwer).

Sphex luctuosus (Smith). Newcastle, August 2 (R.). Meeker, August 9 (R.).

Crabro dilectus Cresson. Meeker, August 9 (R.).

Ephuta fulvohirta Cresson. Newcastle, August 9 (R.); between Newcastle and Rifle Gap, August 3 (R.).

COLEOPTERA

These have all been kindly determined by Mr. H. C. Fall. They were collected by Mr. Robbins.

CARABIDÆ

Carabus tædatus Fabricius. Buford, August 20.

Pterostichus protractus Lec. Buford, August 20; Fitzgerald's Ranch, September 1.

Pterostichus longulus Lec. Buford, August 20.

Amara polita Lec. Buford, August 20.

Harpalus ellipsis Lec. Buford, August 20.

Harpalus oblitus Lec. Fitzgerald's Ranch, September 1.

HALIPLIDÆ

Haliplus ruficollis DeGeer. Near Buford, August 20.

DYTISCIDÆ

Bidessus affinis Say. Near Buford, August 20.

Coelambus patruelis Leconte? Near Buford, August 20.

Coelambus impressopunctatus Sch. Near Buford, August 20.

Acilius fraternus Harris. Near Marvine Lodge, August 25. The only previous Colorado record is from Alamosa.

HYDROPHILIDÆ

Philhydrus diffusus Lec. Reservoir above Rio Blanco Stage Station, August 6.

SILPHIDÆ

Silpha inæqualis Fabr. Marvine Lodge, 9,500 ft., August 29. New to Colorado.

COCCINELLIDÆ

Coccinella transversoguttata Fabr. Buford, August 20. Form *nugatoria* from Little Beaver Reservoir, August 18.

PARNIDÆ

Dryops striatus Lec. Reservoir above Rio Blanco Stage Station, August 6.

BUPRESTIDÆ

Buprestis rusticorum Kirby. Buford, August 20.

SCARABÆIDÆ

Diplotaxis brevicollis Lec. Marvine Lodge, 9,500 ft., August 29.

CERAMBYCIDÆ

Pachyta liturata Kirby. Marvine Lodge, 9,500 ft., August 29.

Tetraopes femoratus var. *basalis* Lec. Little Beaver Creek, August 1.

CHRYSOMELIDÆ

Galeruca externa Say. Buford, August 20.

TENEBRIONIDÆ

Asida polita Say. Meeker, August 8; Little Beaver Reservoir, August 18.

REPTILES AND AMPHIBIANS OF THE UNIVERSITY OF COLORADO

EXPEDITION OF 1909

BY T. D. A. COCKERELL

RANIDÆ (Frogs¹)

Rana pipiens Schreber. Reservoir seven miles northeast of Meeker, August 12; five miles above Ruford, August 24; White River at Meeker, August 11, eaten by *Thamnophis elegans*; Buford, August 22 (T. Duce); swamp near White River, Meeker, August 6.

¹ I take occasion to record that at Medano Ranch, Costilla Co., Colorado, 1909, Mr. E. R. Warren took *Rana pipiens* and *Bufo cognatus* Say.

AMBLYSTOMIDÆ (Salamanders)

Amblystoma tigrinum Green. Meeker, August 16 (A. H. Felger).

COLUBRIDÆ (Water Snakes²)

Thamnophis elegans (Baird and Girard). Meeker and Buford, all with 21 rows of scales and eight upper labials. The Buford specimens are very dark with the lateral pale bands obsolete.

A series of immature specimens puzzled me at first, being conspicuously spotted and rather peculiar in appearance. They all have 21 rows of scales and eight upper labials, except that the Buford specimen has only seven upper labials on one side. In every case, there is only one preocular. The lateral stripes are usually ill defined, but whenever clearly visible, they are on the second and third rows of scales. A noticeable character, more or less visible in all, is a pair of small yellowish spots, close together, on the parietals. The snake from three miles south of Axial has a divided anal, which would throw it out of *Thamnophis* according to the current diagnosis of that genus; but the specimen from reservoir of Curtis Creek, with entire anal, is certainly the same thing. The others also have the anal entire.

The localities of these snakes are: Reservoir of Curtis Creek, seven miles northeast of Meeker, August 12 (Felger); three miles south of Axial, August 14 (Felger); Buford, August 20 (T. Duce); slough on White River, three miles above Meeker, August 17 (T. Duce).

Thamnophis sirtalis parietalis (Say). Buford, August 23; 17 rows of scales; seven upper labials. Mr. A. H. Felger notes that the snake contained two rodents. One of these was still good enough to make a skin, and proves to be *Microtus nanus* Merriam. Another specimen (17 rows of scales, seven upper labials, one preocular) is from Meeker, August 9 (Felger).

IGUANIDÆ (Lizards)

Crotaphytus collaris baileyi (Stejneger). One specimen; femoral pores 18. Rifle Gap, Garfield Co., August 5 (A. H. Felger). New to Colorado. Ditmars, in his *Reptile Book*, ignores *baileyi*, and yet gives measurements of *collaris* which exclude it; consequently it cannot be determined from his book.

Sceloporus undulatus (Latreille). A dark specimen. Meeker, August 10 (A. H. Felger); four miles west of Meeker, August 11 (Henderson and Duce).

Phrynosoma hernandesi (Girard). Two miles southeast of Meeker, August 8 (W. W. Robbins); Meeker, August 10, a juvenile (A. H. Felger).

It is worth while to record that we have a young specimen of *Tropidonotus sipedon* (L.), found at Boulder by Sidney Searcy. This appears to be an addition to the Colorado fauna. We also have *Ophibolus dohiatus gentilis* B. and G., found near Boulder by V. E. Metcalf, July 22, 1904.

BIRDS AND MAMMALS OF NORTHWESTERN COLORADO

BY A. H. FELGER

The following annotated list of 133 species of birds and 51 mammals includes those observed and collected on the expedition and also those reported on good authority from the region. The absence of certain species, especially alpine forms, is due to the fact that our work was done almost wholly between 5,500 and 8,000 feet altitude. Only twice did we pass this latter height, namely, during one day from Marvine Lodge to Marvine Lake and return, and one and a half days from Fitzgerald's to Trapper's Lake and back. At no time were we above timberline and only once above 9,500 feet—while at and near Trapper's Lake for two or three hours.

I endeavored to record the exact number of individuals of the species seen, counting one by one except in cases of large flocks, when the numbers were estimated.

A few places which are extra-territorial with regard to the map (page 103) should be here located: *California Park* lies at the head of Elkhead Creek which empties into Bear River from the north a few miles east of Craig. To the north of this park lie the *Elkhead Mountains*. *Sand Mountain* is at the north edge of California Park and is one of the Elkhead Range. *Bear's Ears Mountain* ascends from the western edge of California Park. *Cedar Springs* are 6 miles west of Craig near Cedar Mountain. They have been a famous watering place for deer, elk and bison.

I desire to express my appreciation and gratitude to the following: Dr. W. H. Bergtold, of Denver, for kind and valuable advance suggestions pertaining to collecting in a field in which he is thoroughly familiar and for helpful notes given me for these lists; Mr. R. S. Ball, of Meeker, who has in the Meeker Hotel a private collection of local birds and mammals, and who has generously given me much information; Mr. E. R. Warren, of Colorado Springs, who has identified some of the more difficult mammals and has gone over my mammal manuscript; Messrs. Enos A. Mills, Samuel Himes, William Green, James Johnson, James Fitzgerald, J. R. Bartlett, W. A. Kyser and H. G. Buckingham, who have

contributed notes; Mr. Dan Frost, the guide who assisted me in securing some large mammals for the University.

BIRDS

7. *Gavia immer*, LOON

Twenty miles from Meeker toward Rifle [Ball's collection]. Migratory in the White River valley [Ball].

62. *Xema sabini*, SABINE'S GULL

A specimen taken four miles below Meeker on the White River, and called by Mr. Ball a Sabine's gull is now in his collection but could not be examined closely because hung close to high ceiling.

130. *Mergus serrator*, RED-BREADED MERGANSER131. *Lophodytes cucullatus*, HOODED MERGANSER

Both reported by Mr. Ball.

132. *Anas platyrhynchos*, MALLARD

A female was seen on our trip about 3 miles below Marvine Lake on Slide Lake, where they are said to breed. Breeding on Trapper's Lake [Himes]. California Park, 1894 [Bergtold].

133. *Anas obscura*, BLACK DUCK134a. *Anas fulvigula maculosa*, MOTTLED DUCK

Young "black mallards" on a pond near Himes' August 28, 1909 [Buckingham]. "Black mallards" in White River valley [Ball]. The absolute identity of these birds is a question.

137. *Mareca americana*, BALDPATE

Reported by Mr. Ball.

139. *Nettion carolinensis*, GREEN-WINGED TEAL

White River valley [Ball, Himes]. Breed in sloughs below Meeker [Himes] California Park, 1895 [Bergtold].

140. *Querquedula discors*, BLUE-WINGED TEAL

White River valley [Ball, Himes]. Breed in sloughs below Meeker [Himes].

141. *Querquedula cyanoptera*, CINNAMON TEAL

White River valley [Ball].

142. *Spatula clypeata*, SHOVELLER143. *Dafila acuta*, PINTAIL144. *Aix sponsa*, WOOD DUCK146. *Marila americana*, REDHEAD150. *Marila collaris*, RING-NECKED DUCK151. *Clangula clangula americana*, AMERICAN GOLDEN-EYE153. *Charitonetta albeola*, BUFFLE-HEAD

All the above species of ducks in the White River valley [Ball].

172. *Branta canadensis*, CANADA GOOSE
Reported by Messrs. Ball and Himes.
173. *Branta bernicla*, BRANT
Reported by Mr. Ball.
190. *Botaurus lentiginosus*, AMERICAN BITTERN
White River, 6 miles above Meeker [Ball's collection].
194. *Ardea herodias*, GREAT BLUE HERON
Twenty miles from Meeker, toward Rifle [Ball's collection]. Common along White River [Ball].
197. *Egretta candidissima*, SNOWY EGRET
Two specimens killed at Meeker in April or May [Ball's collection]. On a lake midway between Trapper's Lake and Glenwood Springs [Himes]. Mr. Shepherd, living 1 mile from Buford, has one taken at Peltier Lake.
202. *Nycticorax nycticorax naevius*, BLACK-CROWNED NIGHT HERON
White River valley [Ball].
205. *Grus canadensis*, LITTLE BROWN CRANE
White River valley [Ball].
206. *Grus mexicana*, SANDHILL CRANE
White River, 1 mile below Buford, August 22, 1909 [Bartlett]. White River valley [Ball]. Breeding in large numbers in marshy spots on ridges north of Himes' [Himes]. A few in California Park, summer 1894 [Bergtold]. James Johnson found a nest with two eggs in June, about 1905, at the head of South Williams Fork. Mr. Ball has one of the eggs. Mr. Johnson also found a nest $\frac{1}{2}$ mile south of Marvine Lodge. He has seen a female regularly during the summer for the past seven or eight years in the same marshy spot between Marvine Lodge and Marvine Lakes, and thinks she nests there. He says, "I have seen as many as eight or ten birds at a time in Lost Park, and have noted them in the other high parks about here."
212. *Rallus virginianus*, VIRGINIA RAIL
Meeker [Ball's collection].
214. *Porzana carolina*, SORA
Meeker [Ball's collection].
221. *Fulica americana*, AMERICAN COOT
Reported by both Mr. Ball and Mr. Himes. The latter states that they breed on the lakes in the vicinity of his place including Trapper's Lake.
226. *Himantopus mexicanus*, BLACK-NECKED STILT
Reported by Mr. Ball.
230. *Gallinago delicata*, WILSON'S SNIBE
One killed at Meeker; numerous in that country [Ball].

254. *Totanus melanoleucus*, GREATER YELLOW-LEGS
California Park, autumn, 1894 [Bergtold].
255. *Totanus flavipes*, YELLOW-LEGS
California Park, autumn, 1894 [Bergtold]. White River valley [Ball].
- 256a. *Helodramus solitarius cinnamomeus*, WESTERN SOLITARY SANDPIPER
Taken on our trip on Curtis Creek, Little Beaver Creek and White River between Meeker and Buford.
261. *Bartramia longicauda*, UPLAND PLOVER
One seen at Marvine Lodge, August 28. A flock of twenty-five or thirty birds, which I judge were of this species, reported as feeding in a field of short alfalfa just south of Meeker, August 10. Mr. Ball also reports them from White River valley.
263. *Actitis macularia*, SPOTTED SANDPIPER
Seen occasionally all along our route, including Trapper's Lake.
264. *Numenius americanus*, LONG-BILLED CURLEW
Reported by Mr. Ball.
273. *Oxyechus vociferus*, KILLDEER
Seen on Good Spring Creek near Axial, on Little Beaver Creek and along White River and at Buford; none seen above the latter place.
289. *Colinus virginianus*, BOBWHITE
294. *Lophortyx californicus*, CALIFORNIA QUAIL
Mr. Ball says, "We had some of both but they seem to have died out." The birds here referred to were doubtless imported into this section.
297. *Dendragapus obscurus*, DUSKY GROUSE
A number seen at Marvine Lodge and at base of Sand Peak near Lost Park. There were young in each flock.
304. *Lagopus leucurus*, WHITE-TAILED PTARMIGAN
Breeding on Devil's Causeway [Bergtold, Himes].
- 308a. *Pediæcetes phasianellus columbianus*, COLUMBIAN SHARP-TAILED GROUSE
Common in California Park, autumn, 1894, also Sand Mt., 1905 [Bergtold]. White River basin [Ball].
309. *Centrocercus urophasianus*, SAGE HEN
We saw several flocks, including young, on Little Beaver Creek, and one flock, including young, near Buford. Reported as plentiful locally in White River valley.
- [310a. *Meleagris gallopavo silvestris*, MERRIAM'S TURKEY
Thus far I have not learned of any wild turkeys being seen in this area.]
316. *Zenaidura macroura carolinensis*, MOURNING DOVE
Seen in numbers all along our route as far up as Himes'. Between Newcastle and Rife Gap two hundred or more were seen in one grain field.

325. *Cathartes aura septentrionalis*, TURKEY VULTURE
Along White River [William Green].
331. *Circus hudsonius*, MARSH HAWK
One seen on Little Beaver Creek, four from Meeker to Buford, one from Buford to Fitzgerald's.
332. *Accipiter velox*, SHARP-SHINNED HAWK
Only one seen on the trip, between Rifle Gap and Rio Blanco Stage Station.
- 337^b. *Buteo borealis calurus*, WESTERN RED-TAIL
Noted here and there all along our route, one being seen at Trapper's Lake.
- 347^a. *Archibuteo lagopus sancti-johannis*, ROUGH-LEG
348. *Archibuteo ferrugineus*, FERRUGINOUS ROUGH-LEG
A number of hawks which appeared to be rough-legs were seen but none taken. The species was, therefore, not determined.
349. *Aquila chrysaetos*, GOLDEN EAGLE
Noted in numbers ranging from one to eight along our route as far as Buford, where the last one was observed.
352. *Haliaeetus leucocephalus*, BALD EAGLE
One killed 5 miles south of Meeker [Ball's collection]. A number of Bald Eagles especially near Rangely; not so many bald eagles as golden eagles in the upper White River valley [Ball]. A pair has nested 2 miles from Himes' each of the last five years [Himes].
- 356^a. *Falco peregrinus anatum*, DUCK HAWK
Reported by Mr. Ball.
360. *Falco sparverius*, SPARROW HAWK
Common to abundant all along our route except between Himes' and Trapper's Lake, where none were seen.
364. *Pandion haliaetus carolinensis*, OSPREY
Reported by Mr. Ball.
366. *Asio wilsonianus*, LONG-EARED OWL
Only one seen on the trip—near Marvine Lodge, August 28, 1909.
367. *Asio flammeus*, SHORT-EARED OWL
Only two seen on the trip—both along Good Spring Creek near Axial.
- 375^a. *Bubo virginianus pallescens*, WESTERN HORNED OWL
One seen near Newcastle and another heard hooting at Marvine Lodge. Mr. Green says they roost upon the flour mill in Meeker.
376. *Nyctea nyctea*, SNOWY OWL
Reported by Mr. Ball.

378. *Speotyto cunicularia hypogæa*, BURROWING OWL

Both Mr. Ball and Mr. W. A. Kyser state that they have seen these owls in the Meeker district. Strange enough, in all the prairie-dog towns that we passed, not a burrowing owl could be found, though I watched carefully for them. *

379. *Glaucidium gnoma*, PYGMY OWL

But one noted—on Good Spring Creek near Axial.

385. *Geococcyx californianus*, ROAD-RUNNER

Has been seen on Montgomery's Ranch, about 3 miles below Meeker [Ball].

390. *Ceryle alcyon*, BELTED KINGFISHER

One noted at each of the following places: Meeker, Buford, Marvine Lodge and Himes'.

393e. *Dryobates villosus monticola*, ROCKY MOUNTAIN HAIRY WOODPECKER

Two birds, apparently of this species, noted, one at Buford, the other at Marvine Lodge.

402a. *Sphyrapicus varius nuchalis*, RED-NAPE SAPSUCKER

A bird that I took to be of this species was seen near Meeker and another near Marvine Lake.

404. *Sphyrapicus thyroideus*, WILLIAMSON'S SAPSUCKER

A bird which appeared to be of this species seen near Himes'.

408. *Asyndesmus lewisi*, LEWIS' WOODPECKER

One taken at Meeker and another at Buford; none seen elsewhere.

413. *Colaptes cafer collaris*, RED-SHAFTED FLICKER

Common along our whole route.

418. *Phalænoptilus nuttalli*, POORWILL

One seen near Little Beaver Creek. White River valley [Ball].

420a. *Chordeiles virginianus henryi*, WESTERN NIGHT-HAWK

Common on almost the entire trip as far up as Marvine Lodge, where it was last seen.

425. *Aëronautes melanoleucus*, WHITE-THROATED SWIFT

A colony of about twenty-five seen near Axial on a cliff overlooking Good Spring Creek. Another cliff, which appeared to be a colony site, where a single Swift was seen, was found along White River about 10 miles above Meeker.

432. *Selasphorus platycercus*, BROAD-TAILED HUMMINGBIRD

From one to five noted here and there all along our route as far up as Himes'.

447. *Tyrannus verticalis*, ARKANSAS FLYCATCHER

Common all along our route as far up as Buford, but none seen above that point. Specimens were taken here and there, and careful search was made with an excellent pair of field binoculars for *T. vociferans*, but none of this species were found.

457. *Sayornis saya*, SAY'S PHEBE
Occasional from Newcastle to Axial and Little Beaver Creek, but none noted beyond this point.
462. *Myiochanes richardsoni*, WESTERN WOOD PEWEE
Occasional throughout our journey.
466. *Empidonax trailli*, TRAILL'S FLYCATCHER
Adults and young taken at Rifle Gap; none recorded elsewhere.
- [474c. *Otocoris alpestris leucolæma*. DESERT HORNED LARK
Not a single bird of this common species was seen on the whole trip.]
475. *Pica pica hudsonia*, MAGPIE
Common almost everywhere; locally abundant; flocks of from twenty to sixty were seen several times.
- 478b. *Cyanocitta stelleri diademata*, LONG-CRESTED JAY
Seen here and there all along our route, in numbers ranging from one to twelve.
480. *Aphelocoma woodhousei*, WOODHOUSE'S JAY
A number observed between Newcastle and Rifle Gap; none seen elsewhere.
- 484a. *Perisoreus canadensis capitalis*, ROCKY MOUNTAIN JAY
Noted only about Marvine Lodge, Marvine Lakes, Trapper's Lake, and Mud Springs.
486. *Corvus corax sinuatus*, WESTERN RAVEN
Three seen between Rifle Gap and Meeker, sixteen in a flock near Meeker, and two near Axial. Mr. Himes reports them common about his place.
491. *Nucifraga columbiana*, CLARKE'S NUTCRACKER
None seen on our trip, but Mr. Himes reports them abundant about his place at times.
492. *Cyanocephalus cyanocephalus*, PINYON JAY
Many seen at Newcastle, one flock containing about two hundred birds; a flock of about twenty-five at Rifle Gap; about one hundred and thirty between Rifle Gap and Rio Blanco Stage Station; one between Meeker and Axial; about fifty between Buford and Marvine Lodge; and about forty between Fitzgerald's and Himes'.
494. *Dolichonyx oryzivorus*, BOBOLINK
Two young birds shot about 7 miles northeast of Meeker, August 17. This establishes to a certainty their breeding near Meeker and in the state.
495. *Molothrus ater*, COWBIRD
Noted at Meeker, Axial, Little Beaver Creek and Fitzgerald's.
497. *Xanthocephalus xanthocephalus*, YELLOW-HEADED BLACKBIRD
Noted in only two places—a flock of about twenty-five near Meeker and a flock of about twenty, 7 miles north by east of Meeker.

498. *Agelaius phoeniceus neutralis*, SAN DIEGO REDWING, THICK-BILLED REDWING
A flock of about 30 seen near Rifle Gap, 6 near Meeker, 4 on Little Beaver Creek, about 75 near Buford and 10 at Himes'. Two specimens taken; identified by Mr. H. C. Oberholser of the Department of Agriculture.

501. 1. *Sturnella neglecta*, WESTERN MEADOWLARK

Common as far as Little Beaver Creek; none seen after leaving that locality.

508. *Icterus bullocki*, BULLOCK'S ORIOLE

Only one seen on the trip, at Meeker.

510. *Euphagus cyanocephalus*, BREWER'S BLACKBIRD

Abundant in suitable localities all along the route as far as Buford, where the last were seen. Near Meeker I saw from two to three thousand flocked together in an irrigated alfalfa field. The number of Brewer's Blackbirds over the area traversed was far in excess of that of the Red-wings or Yellow-heads. Residents also report that there are comparatively few of the two latter.

515a. *Pinicola enucleator montana*, ROCKY MOUNTAIN PINE GROSBEEK

Two seen near Marvine Lodge and one near Mud Springs. Mr. Ball has five specimens killed at Windermere Lodge, 27 miles above Meeker, along the North Fork.

519. *Carpodacus mexicanus frontalis*, HOUSE FINCH, CALIFORNIA LINNET

To my surprise not one of this species was seen on the trip, but Mr. J. T. Duce, formerly a resident of Newcastle, says there are a few of them in that town.

524. *Leucosticte tephrocotis*, GRAY-CROWNED ROSY FINCH

Four mounted birds, killed in Meeker [Ball's collection].

529. *Astragalinus tristis*, AMERICAN GOLDFINCH

One noted at Meeker and quite a number along Good Spring Creek near Axial.

530. *Astragalinus psaltria*, ARKANSAS GOLDFINCH

Saw several at Newcastle, common at Meeker and Axial, and noted one at Buford. I saw in Meeker a young bird of this species, just able to fly. It was doubtless hatched in or near the town.

533. *Spinus pinus*, PINE SISKIN

Taken between Marvine Lodge and Marvine Lakes, August 24, and several seen at Mud Springs, September 2.

Passer domesticus, ENGLISH SPARROW

Found it common in Newcastle and Meeker, and saw one at a farmhouse near Rifle Gap; none seen elsewhere.

540a. *Poœcetes gramineus confinis*, WESTERN VESPER SPARROW

Common all along our route as far as Buford; none seen beyond there.

552a. *Chondestes grammacus strigatus*, WESTERN LARK SPARROW

Seen occasionally from Newcastle to Meeker and vicinity, but not beyond.

560a. *Spizella passerina arizonae*, WESTERN CHIPPING SPARROW

A great number of sparrows, apparently *Spizellas*, were seen from place to place not close enough for certain identification. Many were doubtless of the above species. The only ones positively identified as such were at Newcastle and Marvine Lodge.

562. *Spizella breweri*, BREWER'S SPARROW

Abundant throughout as far as Buford; none seen above there.

569b. *Junco phænotus caniceps*, GRAY-HEADED JUNCO

None seen until we reached Buford, where about twenty were noted, August 25. Seen also near Marvine Lodge, Himes' and Mud Springs.

581b. *Melospiza melodia montana*, MOUNTAIN SONG SPARROW

First seen at Rifle Gap, whence they were common until we passed 2 or 3 miles beyond Himes'; here the last were seen.

588a. *Pipilo maculatus montanus*, MOUNTAIN TOWHEE

Seen along Alkali Creek near Newcastle, at Rifle Gap and on Little Beaver Creek.

592. 1. *Oreospiza chlorura*, GREEN-TAILED TOWHEE

First noted at Rifle Gap, thence seen in suitable localities all along our route up to a point 2 or 3 miles above Himes', where the last one was noted.

596. *Zamelodia melanocephala*, BLACK-HEADED GROSBEEK

Two adults seen and one young taken at Rifle Gap. Therefore, a breeder in that vicinity.

599. *Passerina amoena*, LAZULI BUNTING

Two at Newcastle, seven near Rifle Gap and two near Buford.

605. *Calamospiza melanocorys*, LARK BUNTING

Seen in only one narrowly restricted area, the same as that in which the Bobolinks were found, about 7 miles north of east of Meeker. There were ten or a dozen birds, some of which appeared to be young.

607. *Piranga ludoviciana*, WESTERN TANAGER

Only one seen—at Rifle Gap. Mr. Ball has a mounted specimen killed at Meeker.

611. *Progne subis*, PURPLE MARTIN

Two seen on the trip—a pair (male and female) in Lost Park, September 1.

612. *Petrochelidon lunifrons*, CLIFF SWALLOW

Seen at Rifle Gap, Meeker, Axial, Little Beaver Creek and Buford, but not beyond this point. In numbers they ranged from half a dozen to several score.

613. *Hirundo erythrogaster*, BARN SWALLOW

Found them common locally almost all the way to Buford; none seen above that place.

615. *Tachycineta thalassina lepida*, VIOLET-GREEN SWALLOW

Found two pairs that had taken possession of an old dead tree near Marvine Lodge, and saw several more between Fitzgerald's and Himes'.

616. *Riparia riparia*, BANK SWALLOW617. *Stelgidopteryx serripennis*, ROUGH-WINGED SWALLOW

At various points numerous swallows, which I took to be one or both of these two species, were seen. None being taken, their identity is uncertain.

618. *Bombycilla garrula*, BOHEMIAN WAXWING619. *Bombycilla cedrorum*, CEDAR WAXWING

Mr. Ball records waxwings for his vicinity, but the species is not known.

622a. *Lanius ludovicianus excubitorides*, WHITE-RUMPED SHRIKE

Saw only three on the whole trip; two at Little Beaver Creek and one at Buford.

629b. *Lanivireo solitarius plumbeus*, PLUMBEOUS VIREO

One taken at Buford. I think I saw others of this species, but did not collect them and identification is not positive.

652. *Dendroica aestiva*, YELLOW WARBLER

Noted singly or in pairs here and there as far up as Marvine Lodge.

656. *Dendroica auduboni*, AUDUBON'S WARBLER

A flock of about twenty-five seen near Marvine Lodge. Mr. Ball has one killed at Meeker.

701. *Cinclus mexicanus unicolor*, DIPPER

Seen only in two places, one near Marvine Lake, the other between Fitzgerald's and Himes'.

702. *Oroscoptes montanus*, SAGE THRASHER

Very common in the sage-brush areas between Newcastle and Rifle Gap. None seen up the White River after leaving Meeker.

704. *Dumetella carolinensis*, CATBIRD

One noted at Newcastle, two at Meeker, one at Buford and one at Fitzgerald's.

715. *Salpinctes obsoletus*, ROCK WREN

Common everywhere in suitable localities.

717a. *Catherpes mexicanus conspersus*, CANYON WREN

One collected $2\frac{3}{4}$ miles above Axial, August 13, 1909.

721a. *Troglodytes aëdon parkmani*, WESTERN HOUSE WREN

First seen near Rio Blanco Stage Station; after that noted at Meeker, Axial, Buford and Marvine Lodge.

725c. *Telmatodytes palustris plesius*, WESTERN MARSH WREN

A bird appearing to be of this species was seen in a tule-covered swampy spot between Newcastle and Rifle Gap.

735a. *Penthestes atricapillus septentrionalis*, LONG-TAILED CHICKADEE

Recorded from Good Spring Creek, Meeker and Axial, never more than three having been noted in any given locality.

738. *Penthestes gambeli*, MOUNTAIN CHICKADEE

The only chickadees positively identified as of this species were several seen near Marvine Lodge.

754. *Myadestes townsendi*, TOWNSEND'S SOLITAIRE

One noted near Marvine Lake and another near Marvine Lodge.

759a. *Hylocichla guttata auduboni*, ROCKY MOUNTAIN HERMIT THRUSH

A single bird taken to be of this species was seen near Marvine Lodge.

761a. *Planesticus migratorius propinquus*, WESTERN ROBIN

Common throughout the trip; most numerous along Good Spring Creek near Axial and along North Fork between Fitzgerald's and Himes'.

768. *Sialia currucoides*, MOUNTAIN BLUEBIRD

Abundant on the whole trip, flocks of from fifty to five hundred being seen in some places.

MAMMALS

Cervus canadensis Eixl., ELK

Two bands seen at the base of Sand Peak, one containing seven cows, the other about eight cows and two bulls. Some of the cows had calves. Comparatively fresh signs seen about five miles up House Creek, which empties into Marvine Creek from the west at Marvine Lodge. Reports of settlers indicate that elk are increasing on account of protection of state laws. A band of about a dozen frequents the basin of House Creek, a band of about equal size inhabits the Marvine Lakes country, a few are reported from the head waters of Elk Creek and the south fork of White River. About 500, I am told, roam over the territory between Sleepy Cat Mountain and Sand Peak.

Odocoileus macrourus Raf., WHITE-TAILED DEER

Two of these deer are reported by Enos Mills as seen about fifteen years ago near where Marvine Lodge is now located. These two deer, both does, were alone—not in company with black-tailed deer. These are the only specimens seen by him in the White River country.

Odocoileus hemionus Raf., COLORADO BLACK-TAILED DEER, MULE DEER

Seen on both sides of North Fork but, like the elk, much more numerous on the north side. There has been a deplorable decimation of the deer in this section, as well as in other parts of the state, due to a law passed in 1907 permitting does and fawns to be killed.

Antilocapra americana Ord., PRONG-HORNED ANTELOPE

There seem to be no antelope at the present time in the watershed of the upper White River although reported as still being found in the Bear River basin. Dr.

Bergtold states that in the summer of 1894 they were numerous in California Park and on the flats north of Craig, but scarce there now.

Ovis canadensis Shaw, MOUNTAIN SHEEP

Reported in this area only on Devil's Causeway. Said to be increasing owing to protective laws and difficulty of capture.

Bison bison Linn., BISON, "BUFFALO"

Dr. Bergtold states that in 1894 he found their bones abundant from Rifle Creek to Bear's Ears Mountain. The last survivors in our state of these animals which once roamed in thousands inhabited the Lost Park district. They were known as the "Lost Park Herd." Mr. Ball writes "Last one known at Cedar Springs in 1884, killed by Utes."

Sciurus fremonti Aud. and Bach., PINE SQUIRREL

Common at Newcastle and in the spruce regions of the North Fork basin. Doubtless in all the spruce regions traversed.

Eutamias minimus consobrinus Allen, RELATED CHIPMUNK

Specimens taken at Meeker and Marvine Lodge. Very likely a majority of "little chipmunks" seen on the trip, and reaching up to Trapper's Lake, our altitudinal limit, were of this variety.

Callospermophilus lateralis Say, SAY'S SPERMOPHILE, "BIG CHIPMUNK"

Common all along our journey, including the extremes in altitude.

Citellus elegans Kenn., WYOMING SPERMOPHILE

This "ground squirrel" was in evidence from Rifle Gap to 6 miles above Buford, at which place but one was seen, the last on our trip up the north fork. From Rifle Gap to Meeker and Axial it was common, sometimes very abundant.

Citellus tridecemlineatus parvus Allen, LITTLE SPERMOPHILE

Only one seen; taken between Axial and Meeker, August 14.

Cynomys leucurus Merr., WHITE-TAILED PRAIRIE DOG

First seen on the crest of the divide between Rifle and Meeker; numerous from there on down about 2 miles to Rio Blanco Stage Station on Piceance Creek, and on to Meeker; common locally from Meeker to Axial and along Little Beaver Creek; a few from Meeker up White River to a point $1\frac{1}{2}$ miles below Buford where two, the last of the trip, were seen.

Marmota flaviventer Aud. and Bach., WESTERN WOODCHUCK

Seen in only two localities, between Meeker and Axial, and between Marvine Lodge and Marvine Lakes. Reported to be abundant over the former area.

Castor canadensis frondator Mearns, BEAVER

A colony a short distance below Fitzgerald's and others scattered along down North Fork and White River, according to reports. Dr. Bergtold states that in

former years he has found signs abundant; in the fall of 1905 fresh signs at the head of Williams Fork.

[*Mus norvegicus* Erxl., HOUSE RAT

Thus far I have not located any of this species in this part of Colorado. Mr. Ball states there are none there to his knowledge.]

Peromyscus maniculatus rufinus Merr., TAWNY DEERMOUSE

Four specimens taken at Marvine Lodge.

Peromyscus maniculatus nebrascensis Mearns, NEBRASKA DEERMOUSE

Eight specimens taken at Buford.

Neotoma cinerea orolestes Merr., MOUNTAIN RAT

One taken at Fitzgerald's. In evidence at Marvine Lodge. Throughout the White River valley [Ball].

Microtus nanus Merr., DWARF VOLE

Three taken at Buford and one at Fitzgerald's.

Microtus mordax Merr., CANTANKEROUS VOLE

Two taken at Marvine Lodge.

Fiber zibethicus Linn., MUSKRAT

In a pond about $\frac{1}{2}$ mile below Buford post-office [Bartlett]. Also reported by Mr. Ball.

Thomomys fossor Allen, MOUNTAIN POCKET GOPHER

Many pocket-gopher diggings were found at Buford but none of the gophers were taken. It is probable that they belong to this species.

Erethizon epixanthus Brandt, YELLOW-HAIRED PORCUPINE

Abundant in California Park, summer of 1894, and some at head of Williams Fork in autumn, 1905 [Bergtold]. In all probability they were of this species. White River Valley [Ball].

Ochotona saxatilis Bangs, CONY, PIKA

Six seen, five of which were taken, at Trapper's Lake.

Lepus bairdi Hayden, SNOWSHOE RABBIT

About Buford [Bartlett].

Lepus townsendi Bach., TOWNSEND'S WHITE-TAILED JACKRABBIT

Three white-tailed jackrabbits were seen on Little Beaver Creek and one at Buford. Although not collected they were presumed to be of the above species.

Sylvilagus auduboni baileyi Merr., BAILEY'S COTTONTAIL

Sylvilagus nuttalli grangeri Allen, BLACK HILLS COTTONTAIL

Only one cottontail was seen on the whole trip, and that between Meeker and Axial. There was no opportunity to secure it. Mr. Bartlett says there are cottontails about Buford. I am of opinion that they belong to one of the above species.

Felis hippolestes Merr., MOUNTAIN LION

Common. Some were killed by President Roosevelt on a hunting trip here a few years ago.

Lynx canadensis Desm., CANADA LYNX

This species and *Lynx uinta* reported in this area [Ball].

Lynx uinta Merr., MOUNTAIN BOBCAT

Reported as common. Dr. Bergtold states that he saw a bobcat on the divide between Trapper's Lake and Williams Fork in 1905. I infer that the bobcats of that district are referable to the *uinta* group.

Canis nubilus Say, GRAY WOLF

Dr. Bergtold saw two on the divide between Rifle and Meeker in the autumn of 1898.

Canis lestes Merr. }
Canis mearnsi Merr. } COYOTE

Coyotes were reported abundant. Heard at Rifle Gap and Little Beaver Creek, but none seen. Probably one or both of the above species.

Vulpes macrourus Baird, RED FOX**Vulpes velox** Say, SWIFT**Urocyon cincereo-argenteus scotti** Mearns., GRAY FOX

All reported by Mr. Ball.

Ursus americanus Pallas., BLACK BEAR

Reported to be more common of late than previously. Not long ago Mr. Fitzgerald shot one near his house, and a few days prior to August 24, 1909, one appeared in his garden.

Taxidea taxus Schreber, BADGER

One seen between Rio Blanco Stage Station and Meeker and two between Meeker and Axial. Said to be abundant in the latter half of the stretch of country from Meeker to Axial. Numerous excavations in and about the roads.

Mephitis mephitis hudsonica Rich., NORTHERN PLAINS SKUNK**Mephitis mesomelas varians** Gray, LONG-TAILED TEXAS SKUNK

Common in California Park in summer and autumn, 1894 [Bergtold]. None noted on our trip, but Mr. Ball states that they are present over the area. The inference is that they belong to one or both of the above-indicated forms.

Spilogale gracilis saxatilis Merr., GREAT BASIN SPOTTED SKUNK

Spotted skunks, probably of this species, reported for upper White River country by Mr. Ball.

Mustela americana Turton, PINE MARTEN**Mustela caurina origenes** Rhoades, ROCKY MOUNTAIN MARTEN

Martens reported by Mr. Ball but species not determined; presumed to be the above.

Lutreola vison energumenos Bangs, MINK

Common. Two taken at Marvine Lodge.

Putorius nigripes Aud. and Bach., BLACK-FOOTED FERRET

Mr. R. S. Ball has two specimens which he says were killed within 1 mile of Meeker. This extends its range not only west of the continental divide but far toward the western border of the state.

Putorius arizonensis Mearns, MOUNTAIN WEASEL

Mr. W. W. Robbins, of our party, saw a weasel near Newcastle. Although not determined it was likely of this species.

Lutra canadensis Schreber, OTTER

White River valley [Ball].

Sorex personatus Geoff., MASKED SHREW

One taken at Marvine Lodge.

Sorex obscurus Merr., OBSCURE SHREW

Two taken at Marvine Lodge.

FOSSIL INVERTEBRATES FROM NORTHWESTERN COLORADO

BY JUNIUS HENDERSON

A large number of fossil invertebrates and some seaweeds were obtained from the Mancos and Mesa Verde formations at several localities, as follows: In calcareous shales in the lower part of the Mancos north of Newcastle (Fig. 8), on Little Beaver Creek east of Meeker, on the south side of White River above Meeker, and at about the same horizon north of White River on the east side of the dome east of Meeker.

NEWCASTLE

Inoceramus sp.

Ostrea congesta Conrad

LITTLE BEAVER

Inoceramus cf. *deformis* White

Inoceramus dimidius White

Ostrea congesta Conrad

MEEKER, SOUTH SIDE

Inoceramus sp.

Ostrea congesta Conrad

Fish scales

MEEKER, NORTH SIDE

Inoceramus dimidius White

Ostrea sp.

Plant stems

At the top of the Mancos in the bluff about one mile east of Rifle Gap (Fig. 7) and at the same horizon in the bluff northwest of the Meeker schoolhouse (Fig. 11)

RIFLE GAP

Halymenites major Lesquereux
Serpula markmani Henderson
 Bryozoan undetermined
Inoceramus sagensis Owen
Avicula linguiformis E. and S.
Syncyclonema rigida H. and M.
Liopistha undata M. and H.
Leptosolen sp.
Gyrodes sp.
Lunatia concinna H. and M.
Anchura americana E. and S.
Odontobasis ? sp.
Cylichna volvaria ? M. and H.
 Gastropods undetermined
Baculites compressus Say
Ptychoceras sp.
Placenticerus sp.

MEEKER

Panopæa berthoudi White
Inoceramus cripsi barabini Morton
Inoceramus sagensis Owen
Avicula nebrascana E. and S.
Avicula linguiformis E. and S.
Ostrea sp.
Syncyclonema rigida H. and M.
Mytilus subarcuatus M. and H.
Goniomya americana M. and H.
Thracia gracilis M. and H.
Liopistha undata M. and H.
Eriphyla gregaria ? M. and H.
Lucina sp.
Sphæriola ? *cordata* M. and H.
Legumen ? sp.
Leptosolen ? sp.
Lunatia sp.
Spirocnema ? sp.
Cylichna sp.
 Gastropods undetermined
Baculites compressus Say
Baculites ovatus Say
Scaphites nodosus Owen
Placenticerus intercalare M. and H.
 Fish scales

Between the lowest and next to the lowest well-marked sandstone ledges of the Mesa Verde on the east side of Rifle Gap.

<i>Ostrea subtrigonalis</i> E. and S.	<i>Lunatia</i> sp.
<i>Cardium speciosum</i> M. and H.	<i>Odontobasis</i> sp.
<i>Mactra</i> cf. <i>formosa</i> M. and H.	Gastropods undetermined
<i>Gyrodes</i> sp.	

Above next to the lowest well-marked sandstone ledge of the Mesa Verde and not far below the lowest coal vein on the east side of Rifle Gap.

Ostrea subtrigonalis E. and S.
Anomia ratiformis Meek
Corbicula occidentalis M. and H.

In the lower Mesa Verde sandstones on Piceance Creek above Rio Blanco Stage Station.

Halymenites major Lx.

In middle or upper Mesa Verde strata three miles south of Axial.

Ostrea subtrigonalis E. and S.
Anomia micronema Meek

Corbicula occidentalis M. and H.
Corbicula cytheriformis M. and H.

In the upper Mesa Verde, below the upper coal vein, about one mile north of W. B. Blythe's house, on the north side of White River four miles west of Meeker.

Ostrea subtrigonalis E. and S.
Modiola regularis White
Corbicula occidentalis M. and H.
Corbicula cytheriformis M. and H.

Corbicula planumbona Meek
Legumen? sp.
Turritella sp.

The Mancos faunas are strictly marine, that of the lower part being the fauna which elsewhere marks the Colorado group (Benton and Niobrara). The lowest Mesa Verde fauna at Rifle Gap is also marine, characteristic of the Montana group (Pierre and Fox Hills), the chief species being *Cardium* and *Maetra*. The next higher fauna (at Rifle Gap) includes *Anomia rætiiformis*, which at the type locality east of the Front Range is found associated with marine species, but may also have inhabited brackish water, as its relative, *A. micronema*, probably did. *Ostrea subtrigonalis* may be both marine and brackish-water, and *Corbicula occidentalis* is considered a brackish-water form. Above the latter horizon the Mesa Verde faunas are decidedly brackish-water.

It will be noticed that with the exception of the very lowest fauna of the Mesa Verde and one species in next to the lowest, the fossils we found in that formation are species which in eastern Colorado occur in the Laramie, but the finding of marine Lewis shales between the Mesa Verde and the Laramie in the Yampa region indicates that the beds are not assignable to the Laramie.

The *Corbicula* horizon north of Blythe's house is about 200 to 300 feet (estimated) below the lower plant horizon east of his house, which latter is discussed by Professor Cockerell in a subsequent part of the present report. The lower plant horizon is perhaps 300 or 400 feet below the upper plant horizon northwest of the house. Both of these plant horizons occur above the highest coal vein noted by us in that locality, and contain fossil leaves in great abundance, the lower one

being a sandstone and the leaves poorly preserved, while the higher one is a fine clay and the fossils are in good condition.

The *Ostrea-Micronema* horizon south of Axial appears to occur nearer the middle of the Mesa Verde formation than any of the other faunas or floras, though it was impossible to be sure of this without more time for the examination of the region. The specimen of *Geinitzia reichenbachii* stem discussed by Professor Cockerell was found at this point lying on the surface but apparently having come from a few feet below the *Ostrea* and *Micronema*. The two latter fossils form here a ledge of black limestone two or three feet in thickness composed almost entirely of shells. Several such ledges composed of *Ostrea* and *Corbicula* occur north of Blythe's house, and the *Corbicula-Micronema* ledge at Rifle Gap is a solid mass of shells

FOSSIL PLANTS FROM THE MESA VERDE CRETACEOUS

BY T. D. A. COCKERELL

The flora of the Mesa Verde formation appears to be practically identical with that of the Laramie. Lists of species have been given by Knowlton in *Bulletins* 350 and 371 of the U. S. Geological Survey. *Ficus* is prominent, with several species, separable from each other thus:

Apex of leaf somewhat produced; a rounded lateral lobule. . . . *squarrosa* Knowlton.

(This is a species of the Montana formation; the identity of the Mesa Verde plant is considered doubtful.)

Apex of leaf not produced, at most very broad-angled.

Base deeply cordate; size very large *speciosissima* Ward. (Also a Montana formation species.)

Base not at all cordate.

Leaf longer than broad *planicostata* Lx.

Leaf broader than long *latifolia* (Lx.) Kn.

(Both these are characteristic Laramie species.)

There are also Araucarian conifers, palms, cinnamon, magnolia, and various other trees, all indicating a moist and warm climate. Fragments of a dinosaur have been found, and eight genera of aquatic mollusca.

The material brought back by the University of Colorado Expedition of 1909 includes the following recognizable species:

1. From three miles south of Axial, in light reddish rock, collected by Terry Duce. This is considered to be about the middle of the Mesa Verde formation.

Geinitzia reichenbachii (Geinitz) Hollick and Jeffrey. A remarkable piece of stem, herewith figured (Fig. 13). It has a diameter of 13 mm., and as may be seen from the figure, has an extraordinary resemblance to many of the Palæozoic Lycopodiaceous stems, as for instance *Ulodendron minus* Lindley and Hutton. As it was difficult to imagine what a plant of this type could be doing in the Cretaceous, I turned to the conifers, and found at once considerable resemblance even to the living genus *Araucaria*. At this point I consulted Professor A. C. Seward, who kindly wrote giving a number of pertinent references, the most significant being those to Fontaine's Potomac Flora (*Monog. XV*, U. S. Geol. Survey, 1889). Here I found (Plate CXIX, f. 5) a fragment of a similar stem figured, and referred to *Sequoia reichenbachii* (Geinitz) Heer. This at once connected with the fact that Knowlton records *S. reichenbachii*, on foliage characters, from four localities in the Mesa Verde. Hollick and Jeffrey (*Mem. N.Y. Bot. Garden*, III, 1909, p. 38) have lately shown that *S. reichenbachii* is no *Sequoia*, but a member of the Araucarian genus *Geinitzia*. Whether the Mesa Verde plant and numerous others from different localities and formations are correctly ascribed to a single species, *G. reichenbachii*, may be held at least doubtful. In all probability several distinct species are represented, but in the absence of proof we must follow the current usage of authors. The resemblance of this Araucarian Conifer to a Lycopodiaceous plant of an earlier period is especially significant in view of the probability that there exists a real relationship between these groups. A full and luminous discussion of this question has been given by Mr. A. C. Seward and Miss S. O. Ford in the *Philosophical Transactions of the Royal Society*, Series B, Vol. 198, pp. 385-98.

2. From the upper plant horizon, N. W. of Blythe's house, 4 miles west of Meeker, collected by Messrs. Henderson, Blythe and Kyser.

Myrica torreyi Lx. Very characteristic; submarginal vein more distant from margin than in the original type.

Geonomites goldianus Lx. Large pieces.

Sabalites grayanus Lx. This is recorded from the Mesa Verde by Knowlton with a query. Our specimen, kindly presented by Mr. W. B. Blythe, is well preserved, though imperfect, and is herewith figured (Fig. 14); it very likely represents a species distinct from the original type of *S. grayanus*, but it may very well be included in the species as it has been currently understood. A large specimen, also imperfect, was donated to the university by Mr. J. L.

Riland, who found it on the bluff north of Meeker. It is probably from a slightly lower horizon.

Ficus speciosissima Ward. Showing the base very well.

Ficus planicostata Lx. Good material.

3. From East of Blythe's house; collected by Terry Duce.

Geinitzia reichenbachi (Gein.) H. and J. A fragment of foliage which might well belong here. This is in the sandstone, and belongs to a lower horizon than the others.

There are also a few other imperfectly preserved species which I hesitate to identify.

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FIG. 7.—Mancos-Mesa Verde contact east of Rifle Gap. Sage-brush is abundant along the roadsides. This shrub extends for a distance up the slope; it is replaced there by pinyon pine and cedar.



FIG. 8.—Hill of lower Mancos shale northeast of Newcastle. The steep and easily eroded sides are very destitute of vegetation. A uniform stand of sage-brush in the foreground, extending to the base of the hill.



FIG. 9.—Rifle Gap, looking down stream. Mesa Verde formation dipping southeast. Coal-mine dumps on the right.



FIG. 10.—Valley of Good Spring Creek, south of Axial, cut into Mesa Verde formation. Note fringe of willows along the stream and strip of oak along base of slope on left. The cultivated areas were originally covered with sage-brush.



FIG. 11.—Meeker from the south, with White River in foreground and Mesa Verde bluff in background. Upper Mancos shale at base of cliff. *Populus angustifolia* is the principal tree along the stream sides. The bluff is scattered over with pinyon pine and cedar.



FIG. 12.—Nesting site of white-throated swifts about 9 miles east of Meeker, Colo.

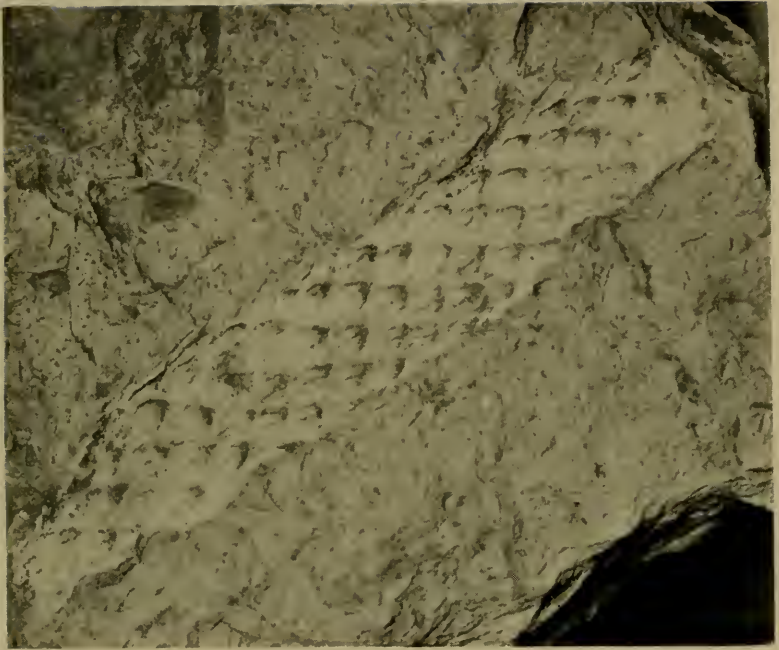


FIG. 13.—*Geinitzia reichenbachi* [Illustrating Professor Cockerell's paper, "Fossil Plants from the Mesa Verde Cretaceous"].

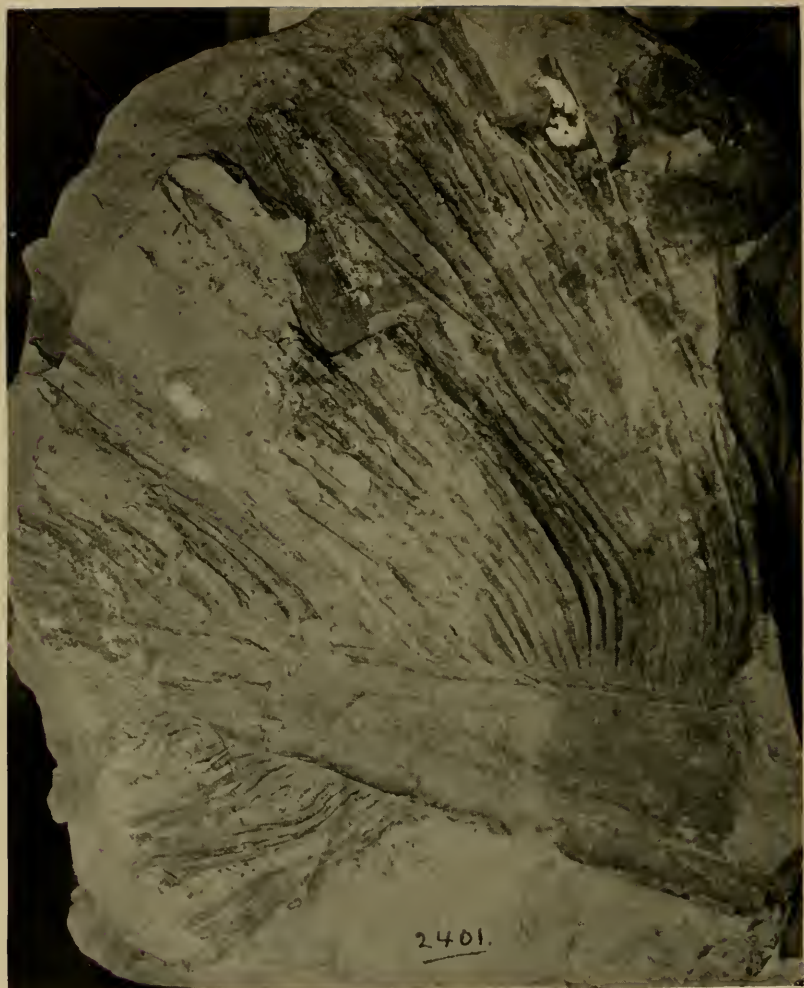


FIG. 14.—*Sabalites grayanus* [Illustrating Professor Cockerell's paper, "Fossil Plants from the Mesa Verde Cretaceous"].

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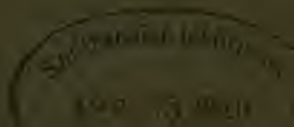


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CONTENTS

	PAGE
1. THE DECLINING BIRTHRATE	159
JOHN BURTON PHILLIPS, PH.D. Professor of Economics and Sociology	
2. AN INTRODUCTION TO THE STUDY OF ROCKY MOUNTAIN BEES	179
T. D. A. COCKERELL Professor of Systematic Zoölogy and W. W. ROBBINS, M. A. Instructor in Biology	

THE DECLINING BIRTHRATE

BY JOHN B. PHILLIPS

"The most decisive mark of the prosperity of any country is the increase of the number of its inhabitants." This statement written more than one hundred years ago by Adam Smith has been generally accepted by publicists to the present day. Statesmen are thinking of possible military necessities, captains of industry want laborers, and new countries need men to develop their resources. With these demands for an additional labor supply, it is not strange that any indication of a decline in the future supply of men is viewed with alarm.

The natural increase of a population is by excess of births over deaths, and growth in this way is possible only when the excess of the birthrate is not lost by a high infant deathrate. A high birthrate does not necessarily indicate a great increase in population. Unless we know that this high birthrate is not accompanied by a heavy deathrate, we cannot be sure that the natural increase of the population is large. Thus, in Russia where the birthrate is 49.5 per 1,000, 31 per cent. of all infants die before the end of the first year; in Bavaria the rate is 36.8 but 24 per cent. die during the first year; in Norway, the rate is 30 and 9 per cent. are likewise lost.¹

It thus appears that the birthrate alone is not a clear indication of the increase of the population of any country. It is nevertheless of sufficient importance in this respect to excite alarm by its decline. In the future medical science may considerably reduce the deathrate, but however great this reduction may be, it cannot be expected to counterbalance the effect of a constantly declining birthrate which if continued will result in a less numerous population. A comparison of the birthrates of the various countries is therefore important indicating as it does various social and economic conditions prevailing among the different peoples.

¹ Ross, "Western Civilization and the Birthrate," *Publications of the American Economic Association*, Vol. VIII, No. 1, p. 84, February, 1907.

The following tables show the variations of the birthrates in the principal countries since 1856:

AVERAGE ANNUAL BIRTHRATES BY DECADES—1856 TO 1905;* LIVING BIRTHS TO 1,000 WOMEN 15 TO 49 YEARS OF AGE

Country	1856 to 1865	1866 to 1875	1876 to 1885	1886 to 1895	1896 to 1905
England & Wales.....	134	139	135	118	104
Scotland.....	132	136	133	121	111
Ireland.....	...	113	101	92	89
Denmark.....	129	124	133	128	118
Norway.....	132	120	127	125	119
Sweden.....	128	120	119	117	110
Russia.....	...	...	...	...	201
Finland.....	...	133	142	135	130
Austria.....	...	147	149	148	145
Hungary.....	...	166	172	172	155
Switzerland.....	...	116	117	110	109
German Empire.....	...	151	153	146	141
Prussia.....	156	147	153	149	143
Bavaria.....	...	153	159	146	145
Saxony.....	151	159	167	157	140
Wurtemberg.....	147	164	162	139	139
Baden.....	...	149	144	130	135
Netherlands.....	134	144	150	142	133
Belgium.....	127	131	132	118	114
France.....	101	103	99	89	85
Spain.....	144	...	141	137	...
Italy.....	...	146	148	149	138
New South Wales.....	...	...	...	150	116
Massachusetts.....	...	...	86	92	90

* KUCZYNSKI, "Zur Statistik der Fruchtbarkeit," *Jahrbücher für Nationalökonomie und Statistik*, Vol. XC, p. 230, December, 1907.

In the United States where statistics of births are not obtainable, it is possible to show the variation in the birthrate by ascertaining the proportion of children under five years of age to 1,000 women 15 to 49 years of age at each census from 1850 to 1900.

NUMBER OF WHITE CHILDREN UNDER FIVE YEARS TO 1,000 WHITE WOMEN 15 TO 49 YEARS OF AGE (CONTINENTAL UNITED STATES)*

1900	1890	1880	1870	1860	1850	1840	1830
465.....	473	537	562	627	613	744	781

* WILLCOX, *Census Bulletin* 22, p. 23, August, 1905.

NUMBER OF WHITE CHILDREN UNDER FIVE YEARS TO 1,000 WHITE WOMEN
15 TO 44 YEARS OF AGE (CONTINENTAL UNITED STATES)*

	Total	Native Women	Foreign-born Women	Difference in Rate between Native and Foreign-born
1900.....	508	462	710	248
1890.....	517	475	666	191

* WILLCOX, *ibid.* [The increase among the foreign-born is probably due to the immigration between 1890 and 1900. The decrease in the number of children to native women was general in the country except in the North and South Atlantic divisions where there was a slight increase. The greatest decrease was in the North Central, and Western divisions. The decrease was chiefly confined to the cities.]

These tables show a general declining tendency in the birthrate of civilized countries. Whatever the causes of this phenomenon may be, their effect is worldwide. It is highly probable that these causes are social and industrial rather than biological. Changes in social organization and in industry that have intensified the growth of individuality or placed additional obstacles in the young man's path to pecuniary success have tended to lower the birthrate by bringing it in an increasing degree under the control of the will.¹ That the action of the will is the greatest factor in lowering the rate appears from the fact that the marriage rate has declined but slightly; the change appears in the smaller size of modern families. That the lower birthrate is not due to a great increase in the sterility of marriage is shown by the fact that New South Wales with a birthrate lower than that of England has a proportion of sterile marriages less than half as great.² The question then is, What are the changes that have so powerfully affected the will in its relation to the birthrate? Among these changes are the following: the passing of the frontier; increase of wealth and luxury; democracy; prohibition of child labor; increased care of children and consequent nervous strain;

¹ This is especially noticeable in Germany—a nation with a highly developed industrial civilization and at the same time with perhaps the highest birthrate of any modern industrial state. It appears that in that country considerable attention is being devoted to the problem of the high birthrate. There is certainly developing there the desire to reduce the size of the family. The large number of pamphlets treating of methods of preventing conception which have recently appeared and are offered for sale at the bookstores is an indication of the desire for smaller families. There is no law against the public sale of such literature in Germany. In the window of one large bookstore I counted five such pamphlets conspicuously displayed. The price of most of them was below fifty cents.

² Ross, "Western Civilization and the Birthrate," *Publications of the American Economic Association*, Vol. VIII, No. 1, p. 79, February, 1907.

decline of the old form of religious belief; growth of cities, and emancipation of women.¹

The effect of the disappearance of the frontier in diminishing the birthrate must not be overlooked. The disappearance of the opportunities that the frontier has always presented to the poorer classes in American society has had a remarkable effect upon the increase of population among them. As the great increase in any population is always in the poorer rather than in richer classes, the disappearance of the frontier is a cause that will affect the natural increase of that portion of our population that has hitherto furnished the greatest addition to our numerical strength.

The frontier has always been an attractive region to young and active men. Without the laborious years of study that are now demanded by modern education, these ambitious sons could leave the paternal roof and seek homes in the western country, and with a reasonable amount of energy might in time be assured of a competence and rise to positions of honor and dignity in the state. Thus, the free lands of the United States were silently bidding for the labor of able-bodied young men and women, and offering opportunities that to great multitudes of our people appeared more valuable even than higher education and professional life.

Hence it came that the strong and aggressive men and women left their homes and settled and developed this western country. To exploit the natural resources of any country does not require great education. The men who came into the West in an early day were able at once to begin the serious business of life. They married early and reared large families. Now the age at marriage is more advanced and the reason is apparent. The natural opportunities of the United States connected with the exploitation of the virgin soil of the West are gone and the other activities now open to our young men require more preparation. While it may be doubted whether or not the young man has not as many opportunities now as his grandfather had it is quite certain that they are of a different kind: they cannot be seized by the man without education.

¹ Ross, *ibid.* [This article discusses briefly democracy, decay of religious belief, and emancipation of women as factors in the declining birthrate.]

Our people of all classes are therefore becoming persuaded that university training is almost a necessity and the time which the students must spend in securing it requires that the date of their marriage be postponed. When marriages occur later in life the possibility of a large family is reduced; hence, a declining birthrate. This is clearly shown by the following table:

NUMBER OF BIRTHS ANNUALLY PER 1,000 MARRIED WOMEN BY AGES*

Ages	Paris 1896	France 1896	Budapest 1890	Norway 1874-76	Berlin 1887-90
Under 20.....	35.1	36.6	42.8	41.3	50.3
20-24.....	26.3	31.3	35.8	57.9	56.3
25-29.....	15.8	25.6	29.2	43.0	33.6
30-34.....	11.0	17.0	20.6	36.0	22.5
35-39.....	6.2	11.0	14.7	30.0	14.5
40-44.....	....	4.5	5.9	18.1	6.0

* MARCH, L., "Familles parisiennes en 1901," *Journal de la Société de Statistique de Paris*, p. 30, February 1894. [Given in BAILEY, *Modern Social Conditions*, p. 184.]

The above table shows that the birthrate is much higher when the wife is young and that the younger the mother the greater the number of births except in Norway and Berlin and in these two cases the rate decreases rapidly after the mother has reached the age of 25 years. In the other cases the rate decreases steadily from the earliest age at which marriage occurs. This shows that the delay in marriage is not important in that it shortens the period of child-bearing during the years of married life, but the importance of the advancing age at which marriage takes place lies in the fact that it eliminates from married life those years in which there is the greatest probability of births. The likelihood of a number of children being born is twice as great when the wife marries at 20 as when she delays her marriage till 30. In the light of the above figures the fact that "the last child in the average family arrives eleven and a half years after marriage,"¹ and that child-bearing ceases long before the expiration of the possible fertile period, does not prove that the advancing age of marriage is not a powerful cause of the lower birthrate.

It is true that in the civilized countries of Europe where there is no frontier and has not been for many generations the birthrate has been

¹ Ross, "Western Civilization and the Birthrate," p. 80.

declining during the last decade. But this can be explained in part by the prevalence of a condition there which in many ways resembles the effect of the passing of the frontier. It is only in the last two or three generations that modern European nations, with the exception of England, have become primarily industrial or manufacturing nations. In the earlier decades these nations were largely occupied in producing such raw materials as coal, iron, agricultural products, lumber and fish. Such industries as there were, were more open to the person of ordinary ability than is the case with the industries at the present day. To be a coal-miner does not require special training. The same is true of a farmer, fisherman or lumberman. But to be a maker of watches, microscopes or thermometers, requires a long period of apprenticeship.

In recent years a number of the nations of Europe have ceased in considerable degree to devote themselves to the raw-material industries and have begun the finer kinds of manufacturing on a large scale. These industries require of the workers years of preparation and during these years the apprentice cannot marry. Thus it is that the changes in manufacturing industry in the European countries, by closing the door of opportunity to the untrained, have had an effect somewhat similar, though different in degree, to the disappearance of the frontier in the United States.

In the history of the United States nothing has been more conspicuous than the remarkable increase in wealth. Owing to its unequal distribution and the prevalence of the democratic ideal, it is natural that there should be a great increase in competition between the various classes as far as the struggle to secure wealth is concerned.

This is precisely what has occurred. The great prizes that have rewarded the exertions of those who have devoted themselves to exploiting the undeveloped possibilities in the new country, and the cultivation of our democratic ideals have feverishly intensified the struggle for wealth.

In proportion as the standards of a community are determined by the pecuniary culture and where, to a considerable extent, equal opportunities exist, the attempt on the part of those who are not yet included in the wealthy class to reach and become members of this, to them desirable, group, must needs result in lowering the birthrate. The more

ability to pay is a determining factor in modern life, the greater will be the struggle to secure financial power, and as early marriages and large families are serious hindrances in this struggle, it is clear that the economic forces of society will tend of themselves both to delay marriage till a later period and to limit the size of the family on the part of those that constitute the most aggressive section of the community.

This movement is strengthened by the growth of democracy and the doctrine of equality. During the past hundred years the whole world seems to have adopted the philosophy that the highest achievement of the individual is self-realization. This is the culmination of the philosophy taught in the higher institutions of learning. The result is an enormous emphasis on the individual, and upon his opportunities for development and growth. Hence, the increase of education and culture. Hence, also, the demand for regulation of industries to give equality of opportunity to the young man beginning in life. The increase of opportunities for individual growth has increased personal competition. Democracy has stimulated everyone to strive harder to win the race than at any previous time in the history of the world. Modern education has raised the general level of intelligence and the differences in this respect between the various classes of society are not as wide as in the early times when education was a luxury of the rich. Universal education such as prevails in the United States tends also to increase the energy spent in the endeavor to secure material comforts. Cultivating the mind brings about a keener realization of the comforts and luxuries obtainable as the result of labor and study. As the unsubdued lands disappear expansion toward the West is checked, and competition increases. This is conspicuously apparent in the United States and must in some degree be the effect of the system of education so long in force here. James Bryce, perhaps the keenest observer of American conditions, after an absence of twenty years remarked that one of the most striking changes here was the fact that every young man seemed to have a "larger head of steam on" than had his father who started active business life two or three decades ago¹. This is only another way of saying that competition is much keener now than in the earlier period.

¹ BRUCE, "America Revisited," *Outlook*, Vol. LXXIX, p. 734, March 25, 1905.

Since competition is so much fiercer in these modern days means must be taken to prepare better those who are to enter the contest. This increases the time required to be spent in training. It also accounts for the lengthening of the course of study in the professional schools. Formerly not much study was required to enable one to practice medicine or law, but now competition is sharper. Specialists who have spent seven years in study are becoming common.

Again, equality of opportunity keeps a population hopeful and makes it ambitious. As long as there is a possibility of rising by one's own efforts, most individuals will struggle desperately to improve their condition and give their children a good start in life. This is one of the causes that induces American young men and women to devote years to their education and accordingly delays their marriage.

On the other hand, in the countries of Europe where there are fixed classes in society the population is not filled with the ambition to rise. The masses live and die in the class in which they are born. Equality of opportunity is not to be realized and hence their ambition cannot be aroused. Without the hope of attaining to a higher level than that reached by their fathers, there is scant reason why they should spend long years in preparation for a higher calling; they marry early and rear large families.

The same conditions prevailed in the ancient time. Society was then in a more static condition than is the case in Europe today. As a general rule it was impossible for a man to reach a higher class than that in which he was born. His ambition was not spurred by the ideals of democracy. The doctrine of equal opportunity for all men to realize themselves had not been born. The fundamental notion prevailed that the individual was subordinate to the state. In the absence of democracy with its doctrine of opportunity for personal development, with no free education, nor chance to rise to a higher social class, it is not strange that the birthrate did not decline before the arrival of the nineteenth century.

The chief cause in bringing about the limitation of the family in modern times is the utterly different view of society. Urging everyone to struggle for advancement and make the most of himself cannot but

cause smaller families. Individual progress and advancement are expensive. The expense of living is increasing rapidly and there is every reason to think that this expense will continue to increase. It is not wholly due to the temporary increase in the gold supply. Science has taught us the sources of many diseases. Bacteria are partly understood; the danger of infectious disease has to be guarded against; pure food must be provided. While we have learned to prevent many of the diseases that were fatal to our ancestors, and while our food is better and will likely tend to improve greatly in the future, it is also true that we have to pay for the prevention and pure food which we enjoy. We must have our sanitary homes; modern plumbing has become a necessity but it is very expensive. A good home represents more wealth than the ordinary man accumulates during a lifetime. Thoreau thought it a shame that a man should be obliged to toil so many years in order to secure a place in which to rest his head, and pleaded for more simple homes. Regrettable as it is, it is true that the expensiveness of the home necessary to insure health has increased since Thoreau's day.

The increase in the convenience and sanitation of the home is something that must needs be striven for by all the population. Each strives to have the same comforts that others have, and when there is added to this the thought that a home with these improvements is necessary to health, it is idle to expect that there will not be intense striving to secure it.

The growth in the finer sentiments is also important in this connection. The progress of civilization is marked by an increase of what are variously classed as humane sentiments, artistic sense and refinement. We are a less brutal people than were our forebears of a few generations ago. Our culture is superior, our lives are smoother and our tastes are more refined. The use of tobacco by women we class as coarse. Bear-baiting, the pleasure of our English ancestors, would arouse in us only sentiments of disgust. The pleasures of a century ago have no place in the more refined and cultured civilization of today.

But the newer ideals of taste and refinement that have become a part of the lives of modern peoples are not to be realized without effort. To live in tasteful homes and to become refined and cultured costs time

and money. Harmonious furnishings, color schemes in decoration, and all the other things which add so much to the lives we are anxious to live cost time and effort to secure. Young men taught to appreciate such surroundings are not anxious to set up in inferior homes of their own. The same is true of young women likewise trained by our system of democratic education. Hence, both men and women prefer to postpone their marriage in the hope that at a later day they will possibly be better equipped with the means to provide a home suited to their cultivated tastes. The same ideal tends to restrict the size of the family among those already married. The desire for beautiful homes and ease in living competes with the desire for children.

In proportion then as society heeds the behest of the time to rise, develop, expand, progress—in short, to realize itself—in that proportion is it tempted to pause and consider before assuming burdens that stand in the way of these ambitions.

The increase in the appreciation of the needs of childhood, and of the opportunities needed to produce efficient citizens has manifested itself in the great attention that has recently been given to the question of child labor. A very vigorous movement is now on in the United States to prohibit all employment of children under 14 years of age, and to children under 16 who cannot pass a certain educational and physical test. New York and Illinois have recently enacted laws embodying in some degree the above principles. There is also a good deal of agitation to prohibit the employment of children as messengers, newsboys, bootblacks, etc. What is defined as the right to childhood is coming to be recognized. It is proper that society should recognize the right of the child to a healthy development, and an education. But the recognition of this right involves restriction of child labor, and increased taxes for more schoolhouses. When child labor was forbidden in the glass factories at Alton, Ill., in 1893, and the compulsory-education law enforced, a new school house had to be built to accommodate the children that had been previously employed in the factories.¹

This increased attention to the needs of children, the requirement that they shall be kept in school till they are 14 and can read and write

¹ KELLEY, *Some Ethical Gains through Legislation*, p. 64, 1905.

English, has already checked the importation of immigrant children. To the immigrant unaccustomed to American ideals, children are regarded as sources of revenue. A large family does not appear to him in any sense a burden as it often does to the American parent ambitious to send his children through college. When no law interferes, the immigrant can soon find work for his young children as newsboys or bootblacks and is apt to desire a large family for the sake of the revenue. But the enforcement of child labor and compulsory school attendance cannot but lead ultimately to a lower birthrate among the foreign-born citizens of the United States.

The dowry has never become an institution in matrimonial affairs in the United States. As is well known, it is firmly established among the French and has been for several generations. It has never grown up in the United States because it has not been necessary. The institution of dowry is especially suited to countries where there is no superabundance of opportunity. Such is the case in France. Where it is possible for the young man to begin at once without education the exploitation of natural opportunities, as has been the case in the United States, where with a reasonable amount of exertion he can in a few years amass a competence, there is little need that the bride bring to her husband a certain amount of capital. Neither is it important that the father think about the amount of money he will be able to give the sons when they are ready to start in business for themselves. Therefore, the young man marries the girl of his choice without thinking whether or not she has a dowry. He expects to make his fortune by exploiting the natural resources of his country. The American father has not given great attention to the education of his sons as he has thought that they could succeed just as he has done. In this way the presence of undeveloped natural resources in the United States has always been a factor operating to prevent the growth of forethought among the American people. Solicitude for children has not been necessary. As long as there was the possibility of going farther west and, without special preparation, accumulating a competence in a comparatively few years, there was no reason for postponing marriage or desiring smaller families. But of late conditions have changed. More care is needed in training children

to enable them to avail themselves of the opportunities of modern life. There is no evidence that parental care has lessened; on the contrary, the evidence seems to show an enormous increase in the sacrifices made by parents in their endeavor to provide efficient equipment in the way of education for their children. It has been said that at the present day the possible costs in psychical energy of rearing four children are as great as were the similar costs required in grandmother's day to raise eight.¹ So great have the sacrifices on the part of parents become that recently some attention has been given to the ethics of the question whether or not the young man or woman shall allow the father and mother to wear themselves out in order that enough money may be spared to provide the education that the times seem to demand. It is well known that in many homes such sacrifices are made for this purpose that we wonder if, after all, university education should be purchased at such a cost. Shortening the life of the breadwinner is too common in the effort to provide funds for the son or daughter to spend four enormously expensive years in the modern college. George Bernard Shaw in *The Irrational Knot* has enunciated the bold doctrine that the son should have his education even at the expense of any sacrifice on the part of the father and mother. This seems to be the accepted doctrine in many homes, at least it is the principle acted upon by great numbers of middle-class parents in the United States. If this is to be the accepted duty of American parents, it is not strange that some efforts are made to keep the size of the family within the educational possibilities of the income.

In France, the law requiring nearly all the property of the father to be divided equally among the various children, is pointed to as one of the agencies that tends strongly to reduce the birthrate. It is said that the French father, knowing the amount of property he is able to leave to his heirs will be small anyway, is therefore anxious to have fewer heirs since he cannot in any great degree augment the estate. There is no chance for the heirs to avail themselves of new lands and carve out homes at slight expense as has always been the case in the newer countries of the world. Hence, with the absence of this opportunity, the father

¹ COOLEY, *Social Organization*, p. 360, 1908.

cannot help thinking of the other way in which he may leave a considerable amount of property to his children and this is by rearing a small family. Hence, the lower birthrate in that country. In the early part of the nineteenth century, Canning, the English Prime Minister, said this law providing for equal distribution of estates would eliminate France as a military danger.

In the United States custom dictates that the estate of the father must be divided equally among the children. In the past this has not had a serious effect in lowering the birthrate as fathers here have not been greatly concerned about the size of the estate to be left to their heirs. It has already been pointed out that in the past the frontier relieved the father of the necessity of taking forethought in the matter of providing for the welfare of his children. With the disappearance of the frontier, however, there is creeping into the ideas of the American people more of the old-world notion of putting something by for the children, and the desire to have them well started in life is very marked in a number of ways quite unknown fifty years ago. For instance, the desire of most parents at the present time to send their children through college is one form of the expression of the idea that great attention should be given to their welfare. It corresponds in a general way to the dower and expectancy of the French father. The increase of the life insurance business in the United States has been co-ordinate with the disappearance of the frontier. It has marked the growth of forethought among American parents. Therefore, declining opportunities for the advancement of the young men and women have placed an increased charge upon parental love, and the custom of equality of inheritance is making parents realize the increasing desirability of starting the children with a certain economic equipment. The effect is to set in motion forces which tend to limit the birthrate. Thus, the desire to keep the patrimonial estate intact increases with the declining opportunity to secure homes at small expense in the new lands of the West, and will, in the course of time, circumvent the democratic equality of our laws of inheritance by lowering the birthrate.

A characteristic of modern life that has had an important effect on the growth of population is the decay of the older forms of religious belief.

While it may be disputed whether or not there has been any decline of religion, still there can be no doubt that there has been a decline in a certain kind of religious belief, namely, the kind that regards the more important events of human life as the results of the acts of the Deity and which excuses human beings from responsibility. The old idea of an external power interfering in temporal matters, has been in some degree replaced by a certain aggressive self-reliance among the most advanced peoples of the present time, and trust in Providence is limited to spiritual, rather than material, affairs. The public has begun to feel that the deaths of little children once ascribed to the actions of an inscrutable Providence were in considerable degree due to the improper care that was formerly given these infants. By greater care and nursing we have been able to reduce greatly the deathrate not only of infants but of all other classes of the population. To most persons, this is evidence that not all early deaths were due to acts of Providence. Such being the case, it is inevitable that modern people should place more reliance upon themselves than when they felt that destiny alone controlled their lives.

In a recent account of the causes of the stationary population in France,¹ the decline of the older form of religious belief is given a prominent place. For many years according to the French statistics the exhortation of the ministers to be fruitful and replenish the earth has fallen upon deaf ears. The birthrate there is just about equal to the deathrate. It is said that the decline is in part due to the weakening of the belief in the biblical injunction in regard to large families. The decline of this obedience makes it all the more easy for the French people to respond to the promptings of that ambition that is necessarily engendered by the great increase in the production of the comforts with which modern life is surrounded. Hence, we find there the excessive development of thrift and the somewhat rigid institution of the dower—things which aim to insure to the population a greater amount of comfort.

It is well known that in all industrial countries the working-class at the present time does not generally attend religious worship. The workmen are strong of body and exercise vigorously and are consequently persons that would be expected to marry early and have large families.

¹ GUYAU, *The Non-Religion of the Future*, p. 323, 1897.

They are the element of the population that has as a rule the highest birthrate. It follows that when the injunction of religion to multiply and replenish the earth begins to be unheeded by them there will be brought into operation other causes that will tend to reduce the number of births among this hitherto prolific class.

It would be of interest in this connection to ascertain the reason why the church has in some degree lost its influence with the working-people. It is claimed that the chief reason is to be found in the industrial processes of the age. Among the alleged causes for this decline in the old religious belief there is perhaps none more ingenious than that the change in the working-class habit of thought has been brought about by the use of machinery; belief in the supernatural, it is alleged, does not flourish among men who are spending their daily lives in modern industry. He who works among machines must needs give too much attention to cause and effect to have space in his mental life for the play of those fancies that are occupied with the contemplation of the supernatural. This, it is said, accounts for the decline of belief in the more miraculous elements in religion among the industrial class.¹ Intense materialistic activity probably tends to blunt the idealizing faculties of the mind. It may therefore be that machinery is a factor in the decline in church attendance on the part of the working-classes, and the consequent weakness of the biblical injunction in regard to the birthrate.

The congestion of population in cities which has been proceeding steadily since the first census was taken and which is largely due to the growth of industry of a manufacturing nature, has also tended to bring our population more and more under the influences which are reducing the rate of increase. The city populations are more ambitious as a rule than the country dwellers and there the strife to rise in the social scale is keener. Consumption takes place in the presence of the multitude; hence there is greater effort to maintain the standard of living, and sacrifices are made to keep up appearances. It is in the city then where social ambition is greater that the larger family is first discovered to be a burden. The care and expense of several children interfere with the gratification of the various ambitions characteristic of the city dwellers.

¹ VEBLÉN, *Theory of the Leisure Class*. pp. 329, 330, 1899.

Therefore, in the city the decline in the birthrate is first seen. The following figures showing the number of children under five years of age to 1,000 native white women 15 to 44 years of age in the city and country indicate this clearly for the cities of the United States.¹

DECLINE OF THE BIRTHRATE IN CITIES OF THE UNITED STATES
Number of Children under Five Years to 1,000 White Women 15 to
44 Years of Age

	1890	1900	Decrease
City.....	309	296	13
Country.....	523	522	1

The growth of cities has raised the price of rents enormously. Such an increase in rents has increased the cost of living, and the home life which every young man desires is placed well-nigh beyond his reach, unless he belongs to that small class with large incomes when reaching their majority. A still further effect of the city on the birthrate appears in the discrimination in the matter of renting houses to families with children. Landlords in certain parts of our great cities will not rent their houses to persons with more than one or two children, and frequently they object to any children. The parents must therefore seek other and more undesirable quarters of the city, where such discrimination does not exist, and where rents are lower. This, of course, does not have a favorable effect upon the birthrate.

It is said that the improvements in transportation will help this condition, and it is true, but they can never wholly relieve it. The expense of trolley-car transportation and the time consumed in this kind of travel are two factors which it seems can never be entirely eliminated.

The increase in the opportunities for women to earn their own living tends to reduce the birthrate. It makes women less dependent and in consequence they do not marry at so early an age and therefore the size of the family is reduced. It is also true that a woman capable of making her own living is not so easily satisfied in the matter of a husband as was formerly the case. She prefers industry to a bad marriage. In the early days when this industrial opportunity was not open to women,

¹ WILLCOX, *Proportion of Children in the United States. Census Bulletin* (No. 22), p. 23, August, 1905.

great numbers of them made unhappy marriages as there was then no other alternative. Now many of those to whom a desirable opportunity does not present itself do not marry at all. Hence, the increasing proportion of unmarried women between the ages of 20 and 35 in the United States.

UNMARRIED FEMALES IN THE UNITED STATES—NUMBER AND PERCENTAGE OF FEMALES IN EACH GROUP UNMARRIED IN 1890 AND 1900*

AGE GROUP	NATIVE WHITE—NATIVE PARENTS				NATIVE WHITE—FOREIGN PARENTS			
	1890		1900		1890		1900	
	Number	Percent- age	Number	Percent- age	Number	Percent- age	Number	Percent- age
20-24	765,762	48.4	925,631	48.7	448,136	65.4	534,754	64.8
25-29	280,866	23.2	397,000	25.2	181,594	35.0	278,193	37.7
30-34	168,777	14.7	201,697	15.7	81,630	20.3	138,194	23.6

* Census 1900, *Population*, Part II, p. lxxxix

When married women work in factories there is also a tendency to lower the birthrate. Witness the following from Sydney Webb concerning conditions in the mill towns of England:

The decline in the birthrate is exceptionally marked where the inconvenience of having children is specially felt. . . . Where married women habitually go to work in factories, and where their earnings form an important element in the weekly income of the family, the interruption caused by maternity is probably most acutely felt. The enforcement by the Factory and Workshops Acts of 1891 and 1901 of four weeks' absence from employment after childbirth comes as an additional objection. Moreover, in the factory districts the later age at which children can now become productive wage-earners has certainly rendered large families less economically desirable than of yore. It is, therefore, of some significance that the ten towns in all England in which the relative fall in the birthrate between 1881 and 1901 is most startlingly great are Northampton, Halifax, Burnley, Blackburn, Derby, Leicester, Bradford, Oldham, Huddersfield, and Bolton—all towns in which an exceptionally large proportion of married women are engaged in factory work, in textiles, hosiery or boots. He was unable to furnish any statistics of the decline in the birthrate among the married women teaching in the schools, but stated that it was known to be great.¹

The conclusion of this study would seem to be that there is in some

¹ WEBB, SYDNEY, *Fabian Tract*, No. 131. [Mass. Labor Bulletin, Vol. XII, No. 3, p. 157, October, 1907.]

degree a conflict of interest between the individual and the community in the matter of the increase of the population. It would also seem to be clear that there is a pronounced conflict between a high birthrate and a democratic, ambitious and highly competitive people. As long as society is based upon personal competition, and as long as competition takes the form of the pecuniary culture, that is, by personal and social display of wealth in forms of conspicuous wastefulness as a means of showing ability to pay, so long will the birthrate tend to decline. It was long ago pointed out that society based upon competition cannot avoid an increasing rivalry and hence an increasing energy must be spent in that direction. The mad rush to surpass others which is the inevitable result of our religiously inculcating in the minds of the young the duty to "make something of themselves" interferes with the high birthrate of former decades. The family becomes smaller and the decline in the increase of the native stock leaves the country a prey to the swarming millions of the more fecund races. It is in this way that intense personal competition may modify the racial stock.

This phenomenon is apparent in France where the birthrate has been stationary for some time. The beaten races, driven into the more inaccessible regions by the ancient Franks and eking out an existence on the margin of cultivation, are beginning to return to the better soils which are gradually being abandoned because of the decline in the natural increase of the original conquering race. That they are amalgamating with the superior race is shown by the measurements of the skull. The conquering race was of the long skull or dolichocephalic type; the conquered race was brachycephalic. Skull-measurements extending over a period of several decades apparently show a slight increase of brachycephaly among the French people.¹

That such will be the case with the more highly civilized nations of the present time is possible but it is not likely to occur for a long series of generations. It is true, nations rise and fall, but the present condition of the birthrate and its relation to the deathrate do not indicate a speedy decline in the population anywhere, not even in France where the birthrate is but slightly in excess of the deathrate. The birthrate of civilized

¹ Ross, *Foundations of Sociology*, pp. 216, 344, 1905.

countries will probable decline for some years, but there is no evidence to show that it will decline continuously till the point of race-extinction is reached. The following table shows that the birthrate among the native-born in Massachusetts has remained practically stationary since 1870:

BIRTHS PER 1,000 AMONG NATIVE-BORN IN
MASSACHUSETTS*

1870.....	15.93
1875.....	16.50
1880.....	16.22
1885.....	16.43
1890.....	16.49
1895.....	16.58

* BAILEY, *Modern Social Conditions*, p. 104.

Likewise the statistics of the fecundity of the families of the native-born in Massachusetts seem to show that the decline in the birthrate for this class of the population has about reached its minimum. In 1890 the number of children to a family was as great as at any time since 1850.

NUMBER OF BIRTHS PER MARRIAGE IN MASSA-
CHUSETTS AMONG THE NATIVE-BORN*

1850.....	2.5
1855.....	2.4
1860.....	1.9
1865.....	2.1
1870.....	2.2
1875.....	2.4
1880.....	2.2
1885.....	2.4
1890.....	2.4

* *Ibid.*, p. 171.

The facts set forth by the tables seem to indicate that when a certain level is reached the birthrate ceases to decline. This is what common-sense would expect. To the very great majority of the human race, children will always be the greatest interest in life, and while the days when the family numbered from thirteen to twenty-one are gone they have not as yet been followed by the day of the childless family nor are they soon likely to be. It is doubtful if any injury has yet resulted from the decline in the birthrate. Thus far the decline in births has made possible an increase of wealth and consequently better conditions of

living. The population is now better clothed, housed and fed than at any previous time, and its quality is probably much improved.

From a military point of view the decline in the birthrate is important. A reduction of surplus population now utilized for standing armies with which to menace the peace of nations would contribute greatly to international tranquillity. Anything that increases the value of a man and his usefulness to the state, renders his government less disposed to trump up quarrels with other nations which may result in destruction of life. Nations with a stationary population are anxious to avoid war. The declining birthrate, therefore, is one of the factors making for international peace.

It is an error to assume that the present materialistic attitude of the social mind is likely to endure permanently. There is not the slightest evidence that it represents a social psychology that will long obtain. On the contrary, there are indications that at the present time large sections of our population are beginning to question the worth of the sacrifices made in the race for wealth. Exposures of the investigations of the past few years have directed public attention to the questionable sources of many great fortunes, and have made familiar the words "tainted money." Criticism of the manner in which so many fortunes have been made has tended to lessen the social value of wealth, and has done much to direct the attention of the world to the advantages of the simple life. It is coming to be realized that the greatest satisfactions of life are not in extravagant living, but consist rather in the consciousness of duty done and loyalty to high ideals. In so far as these ideas which have been for some time obscured in the struggle for material comforts return again to their proper place in the popular mind, it is likely that there will not be the same antagonism between the birthrate and ambition that has existed during several of the past decades.

Much of the discussion of race-suicide is academic and sentimental and tends to draw public attention away from questions whose study is of vastly more vital interest in their relation to the general welfare. Thus far the improvements in medical and sanitary science have greatly increased the expectation of life and have in some degree compensated for any loss due to the lowering of the birthrate.

AN INTRODUCTION TO THE STUDY OF ROCKY MOUNTAIN BEES

BY T. D. A. COCKERELL AND W. W. ROBBINS

The Rocky Mountain bee fauna is not only remarkably rich and interesting, but in spite of many years of collecting it continues to yield numerous undescribed forms. Among the species described the nesting habits are known only in a few cases, and there is an immense field for interesting research into the biology of these insects. Tables for the separation of many of the species have been published but there has existed no quite serviceable modern work for the determination of the genera, and consequently the beginner has been discouraged at the outset. Nothing can be written which will make the study of bees easy, in the sense of absolving the worker from attention to numerous minute details or substituting anything for his critical judgment; but it is hoped that the present paper will at least make it possible for him to proceed, supposing him to be reasonably intelligent and industrious.

There is given first a summary of the classification adopted, in which most of the genera are distinguished. As an appendix to this follows a very brief abstract of Robertson's classification, which is of great value, but unfortunately inadequate, being based wholly on Illinois species. Finally there is offered an artificial key, which can be used by one unfamiliar with the classification, or the place in the system of the specimen in hand. The numerous illustrations of venation include nearly all the local genera, and can be used to interpret the tables and confirm determinations. It must be remembered, however, that the venation varies a little within specific limits, and of course still more within a large genus.

For the local species, the student will use the tables of Boulder County bees, published in these *Studies*, Vol. IV, June, 1907. The artificial key is mainly to genera, but species have been run in when convenient, these being nearly all additions to the Boulder County list since June, 1907. Several genera, and some species, not at present known from

Colorado have been included in the tables, largely for purposes of comparison. These nearly all live in New Mexico, and consequently may be considered to belong to the Rocky Mountain fauna.

Numerous fossil bees are known from the Miocene shales of Florissant. These are not included in the keys, but it will be useful to present a list. Those marked with an asterisk belong to extinct genera:

<i>Halictus miocenicus</i> Ckll.	* <i>Protomelecta brevipennis</i> Ckll.
<i>Halictus florissantellus</i> Ckll.	<i>Anthophora meljordi</i> Ckll.
<i>Halictus scudderellus</i> Ckll.	<i>Megachile prædicta</i> Ckll.
* <i>Libellulapis antiquorum</i> Ckll.	<i>Anthidium scudderi</i> Ckll.
* <i>Lithandrena saxorum</i> Ckll.	<i>Anthidium exhumatum</i> Ckll.
* <i>Pelandrena reducta</i> Ckll.	<i>Dianthidium tertiarium</i> Ckll.
<i>Andrena sepulta</i> Ckll.	<i>Heriades laminarum</i> Ckll.
<i>Andrena clavula</i> Ckll.	<i>Heriades halictinus</i> Ckll.
<i>Andrena hypolitha</i> Ckll.	<i>Heriades bowditchi</i> Ckll.
<i>Melitta willardi</i> Ckll.	<i>Ceratina disrupta</i> Ckll.
* <i>Cyrtapis anomalus</i> Ckll.	* <i>Calyptapis florissantensis</i> Ckll.

DESCRIPTIVE TERMS

HEAD (See Fig. 2)

Vertex: top of head.

Occiput: region behind the vertex.

Cheeks: region behind the eyes.

Front: region between the vertex and the antennae.

Face: region below the antennae, chiefly occupied by a large central plate, the clypeus.

Ocelli: the three simple eyes on upper part of head.

Malar space: the space between eyes and mandibles.

Antennae: 12-jointed in males, 13-jointed in females; the long basal joint is the scape, the apical part, of many joints, the flagellum.

Facial foveae: depressed areas on each side of face parallel with the eyes.

Labrum: the plate below the clypeus, more or less covered by the mandibles.

The mouth parts are sufficiently explained in the figure. The blade of maxilla (that part of maxilla beyond the palpi) is often called the galea, but it is probably equivalent to the galea and lacinia fused (cf. *Trans. Amer. Ent. Soc.*, Vol. XXIX, p. 185). The tongue is often called the glossa.

THORAX

When the thorax is seen from above, the *prothorax* appears in front, behind the head; it has *lateral lobes*, approaching the *tegulae*, known as the *tubercles*. The large piece following the *prothorax* is the *mesothorax* or *mesonotum*; there may frequently be seen upon it two grooves, the *parapsidal grooves*. The next piece, just behind the level of the wings, is the *scutellum*; the *axillae* are small plates on each side of it, sometimes produced into spines, which are often described as the lateral spines of the scutellum. The *postscutellum*, a short sclerite, follows the scutellum, and behind this is the *metathorax*

propodeum or *median segment*. Morphologically this is considered to be part of the abdomen, but even so, the name *metathorax* is appropriate. The *basal area* of the *metathorax* is just behind the *postscutellum*. The large *sclerites* at the sides of the *thorax* constitute the *pleura*. At the base of the anterior wings are round scalelike bodies, the *tegulae*.

WINGS

The venation of the wings is explained in Fig. 1.

LEGS (See Fig. 3)

The basal part of the leg consists of two short segments, the *coxa* and *trochanter*, followed by the long and robust *femur*, after which comes the *tibia*, with one or more apical spurs. The remaining joints constitute the *tarsus*; of these the first is longer than the others and is called the *basitarsus* or *metatarsus*, the latter term being morphologically incorrect. The last tarsal joint bears the *claws*, between which may be a small pad, the *pulvillus*. The *scopa* is the pollen-collecting apparatus, consisting of modified hairs on the hind legs.

ABDOMEN

Six dorsal segments are visible in the female, seven in the male. The *ventral scopa* is the brush of hairs covering the under surface in certain females.

SCULPTURE

The *tegument* or *chitinous surface* is variously sculptured; *punctate*, *striate*, *rugose*, etc. The terms are self-explanatory, except *punctate* or *punctured*, which refers to small depressions looking like punctures of the surface, but not actual perforations.

SYNOPSIS OF CLASSIFICATION

SOLITARY BEES

- A. Tongue short, broad, obtuse, emarginate at apex. COLLETIFORMES.
 1 Hairy bees; anterior wings with three submarginal cells, COLLETIDAE
 Colletes Latr. (P.)
 2 Black bees with little hair, nearly always very small, face in nearly all the
 species with yellow or white markings; only two submarginal cells, PRO-
 SOPIDIDAE. Prosopis Fabr. (P.)
- B. Tongue more or less elongate, pointed, not emarginate; no ventral abdominal scopa.
 ANDRENIFORMES
 1 Tongue more or less short, dagger-like; marginal cell pointed; usually three
 submarginal cells; maxillary palpi 6-jointed, ANDRENIDAE.
 a Females with facial foveae; basal nervure nearly straight; hind
 trochanters of females with curved tuft of hair. ANDRENINAE.
 Three submarginal cells; mostly black species.
 Andrena Fabr. (P.)
 Two submarginal cells.
 Non-metallic species. Parandrena Rob. (P. D.)
 Metallic green or blue species.
 Diandrena Ckll. (P. D.)
 b Andrena-like bees, with three submarginal cells, the second small;
 tegulae usually large; hind legs in male usually modified; abdomen
 often with opalescent green or blue bands. NOMINAE.
 Nomia Latr. (P.)

* The allied genus *Dieunomia* occurs on the plains. *D. marginipennis*, Cresson, occurs at Rockyford (Gillette) and *D. xerophila* Ckll. at Sterling (Johnson). These are large bees, with the male antennae modified

- c* Females without facial foveae; metallic or black bees, rarely with the abdomen orange or red, distinguished from Andreninae by the strongly curved basal nervure; hind spur of hind tibia in females often with long teeth. HALICTINAE.
- aa* Colors black or greenish, rarely at all brilliant; size often small; three submarginal cells; species numerous.
Halictus Latr. (P.)
- bb* Head and thorax metallic; size very small; like *Halictus*, but with only two submarginal cells.
Dialictus Rob. (P. D.)
- cc* Brilliant green (rarely blue or crimson) species, the color not conspicuously different in the sexes; eyes emarginate in front; a group invading North America from the Neotropical region; tongue sometimes quite long.
Augochlora Smith (S.)
- dd* Brilliant green species, the abdomen sometimes dark or yellowish; males with abdomen striped with yellow and black.
Agapostemon Smith (S.)
- d* Inquilinous or parasitic bees, with the head and thorax black, the abdomen red; three submarginal cells. SPHECODINAE.
Sphecodes Latr.¹ (P.)
- 2 Tongue elongate, though not as long as in some of the higher groups; only two submarginal cells except in *Protandrena*, which has three; never brilliantly metallic, though sometimes (*Perdita*) the head and thorax green; often with yellow markings. PANURGIDAE.
- a* Three submarginal cells; black species, the face with yellow markings; marginal cell truncate at end.
Protandrena Ckll. (S.)
- b* Two submarginal cells.
Marginal cell pointed on costa. Halictoides Nyl.² (P.)
Marginal cell truncate (obliquely in some).
Marginal cell short and very broadly truncate; small species with nearly always light markings on abdomen.
Perdita Smith (N.)
- Marginal cell elongate.
Abdomen with pale markings not due to hair.
Spinoliella Ashm. (N.)
Abdomen without pale markings.
Truncation of marginal cell little oblique.
Pangurginus Nyl. (P.)
Truncation of marginal cell conspicuously oblique; first recurrent nervure meeting first transverso-cubital. Only one species,³ which visits *Malvastrum*.
Greeleyella Ckll. (N.)

¹ The subgenus *Proteraner* Rob. has males which appear in the spring with the females, which is not the case with other Halictinae. For a list of the species of *Sphecodes*, see *Psyche*, pp. 107-110, October, 1907.

² The related Californian genus *Amblyopsis* Ckll. (type *A. ilicifolia* Ckll.) is separated by the short palpi, second and third joints of labial palpi produced on one side apically, and blade of maxilla very short and obtuse. *A. ilicifolia* is a small ($\frac{5}{8}$ mm. long) black bee with greyish-white hair.

³ Since this was written a second species, collected in Texas, has been received.

3 Tongue elongate; parasitic bees, usually highly ornamented, and with no pollen-collecting apparatus.

a Maxillary palpi 6-jointed; a type derived from the Panurgidae, or rather from an ancestral type related thereto but with three submarginal cells; usually wasp-like in appearance, with bright yellow and often red colors; three submarginal cells in all but one or two species; marginal cell pointed on costa. **NOMADIDAE.**

Nomada Fabr.

b Maxillary palpi with two to six joints; usually robust bees, with conspicuous markings due to hair, but without yellow tegumentary markings; a type derived from the Anthophoridae. **MELECTIDAE.**

Maxillary palpi 6-jointed. **Bombomelecta** Patton (N.)

Maxillary palpi 5-jointed, the last joint minute; genus parasitic on *Anthophora*. **Pseudomelecta** Rads. (N.)

Maxillary palpi 3-jointed; body with conspicuous light markings due to appressed hairs; genus parasitic on the Eucerinae. **Triepeolus** Rob. (N.)

Maxillary palpi 2-jointed; size usually smaller than in the last, and silvery area on end of abdomen of female much smaller. **Epeolus** Latr. (P.)

Like *Epeolus*, but with only two submarginal cells.

Phileremus Latr. (P.)

c Maxillary palpi 5- to 6-jointed; small bees usually classed with *Phileremus*, etc., but apparently forming a distinct group. **NEOLARRINAE.¹**

Maxillary palpi 6-jointed.

Marginal cell long, truncate at apex.

Abdomen dull, constricted at the sutures.

Neopasites Ashm. (N.)

Abdomen shining, not constricted at the sutures; genus parasitic on *Spino-liella*. **Oreopasites** Ckll. (N.)

Marginal cell very small and short.

Neolarra Ashm. (N.)

Maxillary palpi 5-jointed; only one submarginal cell; very minute bees. **Phileremulus** Ckll. (N.)

4 Tongue very long; first two joints of labial palpi elongate, sheath-like, last two minute; hairy, pollen-collecting bees, the males often with long antennae, and usually with the clypeus yellow. **ANTHOPHORIDAE.²**

a Paraglossae very short; form robust; Neotropical group reaching the southern border of the United States. **CENTRINAE** (or **Hemisiinae**).

Maxillary palpi 6-jointed.

Clypeus not yellow in male. **Exomalopsis** Spin. (S.)

Clypeus yellow in male; usually only two submarginal cells. **Anthophorula** Ckll. (S.)

Maxillary palpi 4-jointed; large robust, swift-flying bees.

Centris Fabr. = **Hemisia** Klug. (S.)

(The Fabrician *Centris* was a mixture; Schrottky contends that the name is not applicable to our bees.)

b Paraglossae medium, not or hardly exceeding first joint of labial palpi. **ANTHOPHORINAE.**

Maxillary palpi 5-jointed; tongue, labial palpi and maxillary blade extremely long. **Melitoma** Lep. & Serv. (S.)

¹ ASHMEAD, *Bull. Colo. Biol. Assoc.*, No. 1, p. 33, 1890.

² For a list of the species, see *Trans. Amer. Ent. Soc.*, Vol. XXXII, pp. 97-104, 1906.

Maxillary palpi 6-jointed.

Blade of maxilla broad at base, suddenly narrowing to the slender apical portion.

Clypeus dark in male. *Diadasia* Patt. (S.)

Clypeus light in male. *Dasiapis* Ckll. (S.)

(Vachal includes both *Diadasia* and *Dasiapis* in *Ancyloscelis*, a South American genus.)

Blade of maxilla broad, gradually narrowing to the more or less blunt tip.

First recurrent nervure joining second submarginal cell near middle.

Mandibles simple or bidentate.

Anthophora Latr.¹ (P.)

Mandibles tridentate.

Clisodon Patt. (P. D.)

First recurrent nervure joining second submarginal cell at or very near end.

Emphoropsis Ashm. (P. D.)

c Paraglossae very long, hairy. EUCERINAE.

Maxillary palpi 6-jointed.

Tetralonia Spin. (P.)

Maxillary palpi 5-jointed.

Maxillary palpi comparatively long and slender; bees usually found on Cucubitaceae.

Xenoglossa Smith (S.)

Maxillary palpi shorter, fifth joint reduced.

Xenoglossodes Ashm. (S. D.)

Maxillary palpi 4-jointed.

Melissodes Latr. (S.)

(*Xenoglossodes* is nearer to *Melissodes* than to *Xenoglossa*. *Martinella* is a genus found in New Mexico, closely allied to *Melissodes*. The only known species has the flagellum bright yellow in the male.)

C. Tongue long, filiform; two submarginal cells; labial palpi with the basal joints much elongated, the apical minute; under side of female abdomen with a pollen-collecting scopa, except in the parasitic genera. MEGACHILIFORMES: MEGACHILIDAE

1 Eyes hairy;² parasitic group related to the Megachilinae. COELIOXYNAE.
Coelioxys Latr. (P.)

2 Eyes not hairy.

a Non-metallic,² pollen-collecting bees, without colored markings. MEGACHILINAE.

aa Bees of large or medium size.

Marginal cell sharply pointed; face in female with a protuberance; male with a pulvillus.²

Lithurgus Berthold (P.)

(One species in our fauna.)

Marginal cell obtuse; face without a protuberance; no pulvillus in either sex; maxillary palpi 3-jointed.

Megachile Latr. (Many species) (part P., part N.)

bb Small bees, with a pulvillus. OSMIINAE.

Maxillary palpi 3-jointed.

Base of first abdominal segment with a

¹ *Anthophoroides* T. & W. Ckll., from New Mexico, is like *Anthophora*, but with five-jointed maxillary palpi. The only species is *A. valtorum* Ckll.

² Exceptions to these characters are found in certain Old-World species.

smooth area bounded by a strong rim; body coarsely punctured.

Heriades Spin. (P.)

Base of abdomen not thus formed, the basal area not surrounded by a rim; body more delicately punctured.

Chelostoma Latr. (P.)

Maxillary palpi 4-jointed.

Female clypeus smooth and shining, emarginate in the middle; first joint of labial palpi nine-tenths length of second.

Titusella Ckll. (N.)

Clypeus ordinary.

First abdominal segment at base with a wide impunctate basin; male with abdomen ending in four small teeth.

Ashmeadiella Ckll. (N.)

First abdominal segment at base rounded, with a narrow sulcus; male abdomen not ending in four teeth.

Robertsonella Titus (N.)

Maxillary palpi 5-jointed; male antennae modified.

Alcidamea Cresson (one species) (N.)

cc Rather large bees, resembling *Osmia*, but black, with long, parallel-sided abdomen; male with clypeus subemarginate, and antennae approaching the *Alcidamea* type, but without an apical hook; maxillary palpi 5-jointed.

Monumetha Cresson (one species) (N.)

(The few black species of *Osmia* will come in here and will be distinguished by the 5-jointed maxillary palpi, combined with normal antennae in the male.)

b Metallic, dark or brilliant blue or green, pollen-collecting bees, with a pulvillus; maxillary palpi 5-jointed. **OSMIINAE.**

Osmia Panzer (P.)

c Metallic or non-metallic parasitic bees, with or without light markings; postscutellum not toothed. **STELIDINAE.**

Second submarginal cell receiving both recurrent nervures.

Chelynia Provancher (N.)

Second recurrent nervure received at or beyond apex of second submarginal cell. **Stelis** Panzer (P.)

d Non-metallic, sometimes partly red, parasitic bees, rather like *Coeioxys* in form, but eyes not hairy; postscutellum with a median tooth; no pulvilli. **DIOXYNAE.**

Dioxys Lepeletier (P.)

e Black bees with conspicuous yellow or whitish markings; pollen-collecting. **ANTHIDIINAE.**

No pulvillus; cottony material used in preparing nests, which are in burrows.

Anthidium Fabr. (P.)

Pulvilli present; nests made of resin, on rocks, etc.

Dianthidium Ckll. (P.)

D. Pollen-collecting bees with three submarginal cells and a long, filiform tongue, making nests in wood or in stems of plants. *XYLOCOPIFORMES*.

1 Large robust bees; mostly tropical. *XYLOCOPIIDAE*.

Xylocopa Latr. (P.)

2 Small bees; not rare in temperate regions. *CERATINIDAE*.

Ceratina Latr. (P.)

SOCIAL BEES: *APIFORMES*

Eyes hairy; marginal cell very long. *APIIDAE*. *Apis* L. (not native in America.)
Eyes not hairy. *BOMBIDAE*.

Pollen-collecting bees.

Bombus Fabr. (P.)

Parasitic bees, the females without polleniferous areas on hind legs; living in nests of *Bombus*.
Psithyrus Lepelletier (P.)¹

The North American bees may be divided into three groups according to their supposed origin:

- 1 *Nearctic genera*, which have probably inhabited North America during the larger part of Tertiary time.
- 2 *Palaeartic genera*, which have probably reached North America during the Miocene, or derivatives from such genera.
- 3 *Neotropical genera* and their derivatives, which probably for the most part reached America during the latter part of Tertiary time.

These are marked N., P. and S., respectively, in the list above. D. signifies an American derivative.

A few genera, such as *Lithurgus* and *Megachile*, were doubtless common to the New and Old Worlds prior to the Miocene invasion. There can be no doubt that *Megachile* contains elements of Nearctic as well as Palaeartic origin; the truly Palaeartic types are such species as *M. melanophaea*, *M. vidua*, etc.

ROBERTSON'S CLASSIFICATION

Mr. Charles Robertson, in the *Canadian Entomologist*, 1904, has given a classification of the groups of Illinois bees, of which the following is a partial abstract. It is based wholly on the females. Equivalent names in our classification are given within square brackets.

APYGIDIALIA

(Sixth abdominal segment exerted, without a pygidial area)

A. Tongue flat, bilobed; facial foveae present; mandibles bidentate; maxillary palpi longer than blade of maxilla.

¹ Two new species of *Psithyrus* have been collected by Mr. S. A. Rohwer at Eldora, Colorado; they will be published by Mr. H. J. Franklin. One of them extends northward as far as Sitka, Alaska.

COLLETOIDEA [Colletiformes]

PROSOPIDIDAE

(Two submarginal cells; no polleniferous scopa)

COLLETIDAE

(Three submarginal cells; polleniferous scopa present)

B. Tongue filiform; no facial foveae; maxillary palpi shorter than blade of maxilla.

1 Two submarginal cells; labrum longer than wide.

TRYPETOIDEA [Megachiliformes]

STELIDIDAE [Stelidinae and Anthidiinae]

(Claws cleft, inner tooth subapical)

MEGACHILIDAE [Megachilidae, excluding Stelidinae and Anthidiinae]

(Claws simple, sometimes with a basal tooth)

2 Three submarginal cells; labrum wider than long.

a Apex of sixth abdominal segment with a spine or mucro, a little concave before the point; maxillary palpi 6-jointed.

CERATINOIDEA [Xylocopiformes]

CERATINIDAE (Stigma large)

XYLOCOPIDAE (Stigma obsolete)

b Apex of sixth abdominal segment obtuse, without a spine or mucro.

APOIDEA [Apiformes]

APIDAE (hind basitarsus shorter than tibia) [Apidae and Bombidae]

PYGIDIALIA [Andreniformes]

(Sixth abdominal segment exerted or retracted, with a pygidial area)

A. Tongue acute, flat, rarely filiform; second to fourth joints of labial palpi simple; stigma large, rarely middle-sized.

ANDRENOIDEA

Tegulae very large; labial palpi simple; tongue lance-linear, acuminate.
Nomiidae [Nomiinae]

Tegulae ordinary.

1 Labrum free from mandibles, as large as clypeus, shorter than wide, transversely striate, without basal process; labial palpi simple.

Dufoureidae [Halictoides]

Labrum ordinary.

2 Hind tibia and basitarsus broad, with dense simple hairs; labial palpi simple.

Macropodidae [not in our fauna]

Hind tibia and basitarsus ordinary.

3 Marginal cell truncate; two submarginal cells (three in Protandrena); facial foveae present.

Panurgidae

Marginal cell pointed; usually three submarginal cells.

4 No facial foveae; basal nervure strongly bent or arcuate.

Halictidae [Halictinae]

Facial foveae present; basal nervure slightly arcuate.

Andrenidae [Andreninae]

B. Tongue filiform; first two joints of labial palpi flat; labrum large, without basal process; stigma small or middle-sized, rarely large.

ANTHOPHOROIDEA

Scopa absent. Melectidae [Melectidae and Nomadidae]
 Scopa present; three submarginal cells. 1

1 Marginal cell with apex rounded; stigma obsolete or nearly.
 Anthophoridae [Anthophorinae]

Marginal cell lanceolate, apex acute, bent away from costa. 2

2 Vertex crested; paraglossae at least as long as first two joints of labial palpi together; basitarsus broad, with a posterior apical appendage. Euceridae [Eucerinae]

Vertex not crested; paraglossae shorter than first two joints of labial palpi together; basitarsus narrow.
 Emphoridae [Entechnia = Melitoma.]

Protandrena, not found in Illinois, Mr. Robertson would place in Panurgidae, as a subfamily Protandreninae. It has three submarginal cells. Robertson's Emphoridae includes two subfamilies:

Pulvilli absent. Emphorinae: *Emphor* [not in our fauna.]
 Pulvilli present. Entechiinae: *Entechnia*.

Vachal has recently argued that *Entechnia* is the same as the prior genus *Melitoma*, and upon going over the description of the latter, this certainly seems to be correct.

ARTIFICIAL KEY

The numbers following the generic names refer to the figures of wings.

- Only one submarginal cell; minute parasitic bees. **Phileremulus**
- Two submarginal cells. 1
- Three submarginal cells. 42
- 1 Marginal cell sharply truncate at tip, the lower apical corner with an appendicular nervure (Panurgidae). 2
- Marginal cell not thus truncate and appendiculate. 8
- 2 Marginal cell short; small bees with the head and thorax usually metallic, dark green or blue, and the abdomen usually with light spots or bands. **Perdita** (4, 5)
- Marginal cell rather long, more narrowly truncate; head and thorax not metallic. 3
- 3 Abdomen with conspicuous light tegumentary spots or bands. **Spinoliella** (6)
- Abdomen without light tegumentary markings. 4
- 4 Hairy bees, with the abdomen more or less conspicuously banded. **Calliopsis**
- Abdomen shining, black, not banded. 5
- 5 Coarsely punctured; wings very dark; marginal cell obliquely truncate; first recurrent nervure joining second submarginal cell no great distance before its middle. **Pseudopanurgus**
- Delicately punctured; wings hyaline or subhyaline. 6
- 6 First recurrent nervure entering second submarginal cell a considerable distance from its base. **Panurginus** (7)

First recurrent nervure entering first submarginal cell; alpine species (Topaz Butte, Colorado, at flowers of *Drymocallis fissa*, June 23, 1907, S. A. Rohwer).

Panurginus verus Ckll.

First recurrent nervure joining, or almost joining, first transverso-cubital.

7

- 7 Smaller, mountain species; upper corner of apical truncation of marginal cell angular; legs of male dark.

Panurginus cressoniellus Ckll. (7)

Larger species, visiting *Malvastrum* in the foothills and plains; upper corner of apical truncation of marginal cell rounded; legs of male mainly yellow.

Greeleyella beardsleyi Ckll.

- 8 Eyes hairy; parasitic bees, without scopa.

9

Eyes not hairy.

15

- 9 Legs red.

10

Legs dark.

11

- 10 Male about 8 mm. long, with punctures on middle of fifth abdominal segment conspicuously smaller and denser than those of apical half of fourth. (Boulder, July 20, W. P. Cockerell).

Coelioxys edita Cresson

Male over 11 mm. long, with punctures on middle of fifth abdominal segment hardly different from those on apical part of fourth (Boulder, August, at flowers of *Grindelia*, W. P. Cockerell).

Coelioxys deplanata Cresson

- 11 Very small, about 7 mm. long (Boulder).

Coelioxys deani Ckll.

Larger, 10 mm. or over (male *gilensis* sometimes 9 mm.).

12

- 12 Tarsi more or less red.

13

Tarsi dark.

14

- 13 Last ventral segment of female broad, its lateral margins strongly convex, its apex rounded, with a small projection (Boulder, at flowers of *Melilotus alba*, July, S. A. Rohwer).

Coelioxys gilensis Ckll.

Last ventral segment of female narrower, its lateral margins nearly straight, each with a notch (Boulder, July 3, Cockerell.)

Coelioxys rufitarsis rhois Ckll.

- 14 Last ventral segment of female broad, suddenly narrowing to the conoid apical projection (New Mexico, Cockerell; Milwaukee, Wisconsin, Graenicher).

Coelioxys ribis Ckll.

Last ventral segment of female narrow, notched but not abruptly narrowed at the beginning of the apical projection.

Coelioxys moesta Cresson

- 15 Abdomen with yellow or yellowish-white tegumentary bands or spots.

16

Abdomen not thus ornamented.

22

- 16 Pulvillus absent; mostly large bees; females with ventral scopa.

Anthidium (9)

Pulvillus present.

17

- 17 Dark green or blue, the abdomen with light bands.

18

Not metallic.

19

- 18 Hair of vertex pale, of pleura black.

Chelynia pulchra Crawford

Hair of vertex largely black, of pleura pale.

Chelynia elegans Cresson

- 19 Second recurrent nervure joining second submarginal cell before its end; parasitic bees, without scopa. 20
 Second recurrent nervure going beyond end of second submarginal cell. 21
- 20 Abdomen with the bands broken into widely separated spots; very small species (Santa Fé, New Mexico). *Chelynia permaculata* Ckll.
 Abdomen with the bands nearly entire, or several quite entire.
Chelynia monticola Cresson and *C. submarginata* Cresson
- 21 Very small, about 7 mm. long or less, with bright yellow markings; no scopa (Santa Fé, New Mexico). *Stelis rudbeckiarum* Ckll.
 Large, more robust, females with a scopa. *Dianthidium* (10)
- 22 Marginal cell extremely minute; very small parasitic bees. *Neolarra*
 Marginal cell normal. 23
- 23 Head and thorax metallic, blue or green. 24
 Not metallic. 26
- 24 Basal nervure strongly bent or arched; very small species; females with no ventral scopa. *Dialictus* (11)
 Basal nervure straight or little arched. 25
- 25 Stigma well developed; marginal cell more pointed; females without ventral scopa (only one species in our region, visiting *Nothocalais* and allies). *Diandrena* (12)
 Stigma little developed; marginal cell more obtuse at end; females with a ventral scopa on abdomen (many species). *Osmia*¹ (13)
- 26 Third discoidal cell contracted above, the recurrent nervures joining the second submarginal cell not very far apart; small bees. *Phileremus* (14)
 Third discoidal cell not so formed. 27
- 27 Marginal cell at apex very obtuse or subtruncate; small parasitic bees with hind margins of abdominal segments reddish, and abdomen with pale or white spots of appressed scale-like hairs. 28
 Marginal cell pointed. 29
- 28 Abdominal spots white; abdomen reddish (Colorado Springs).
Neopasites pulchellus Cresson
 Abdominal spots dull; insect rather larger and much darker (Boulder, at flowers of *Grindelia*, July 16, 1908, W. P. Cockerell). *Neopasites heliopsis* Rob. (15)
- 29 Head and thorax with yellow or yellowish-white markings; small bees with very little hair, the abdomen black without bands. *Prosopis* (16)
 Head and thorax without light tegumentary markings. 30
- 30 Second submarginal cell quadrate, only moderately narrowed above; first recurrent nervure meeting first transverso-cubital; stigma well developed; wings dusky; thorax not hairy. *Prosopis basalis* Smith, female
 Second submarginal cell more elongate, more narrowed above; thorax hairy.

31

¹ *Chelynia pavonina* Ckll., from Boulder, is like a bright metallic *Osmia*, without ventral scopa. Only one specimen is known.

The following species of *Osmia* were taken at Tolland in 1909 (Robbins): *O. longula* Cress., *O. brevis* Cress., *O. propinqua* Cress., *O. pentstemonis* Ckll.

- 31 Marginal cell at apex reaching costal margin of wing; females without ventral scopa. **Halictoides** (17)
Marginal cell at apex more or less distinctly separated from costa; females with a ventral scopa. 32
- 32 Females with two large protuberances on middle of face, the space below them smooth and shining; males with the abdomen ending in a point; marginal cell sharply pointed, away from costa (one species, a rather large bee, in our region). **Lithurgus** (18)
Females and males not thus distinguished. 33
- 33 Clypeus smooth and shining, emarginate in the middle; a small bee about 8 mm. long; ventral scopa light fulvous or orange (male unknown). **Titusella pronitens** Ckll. (19)
Clypeus not thus smooth. 34
- 34 No pulvilli on feet; species usually of medium size or large; ventral scopa usually pale (many species). **Megachile** (25)
Pulvilli present. 35
- 35 Rather large bees, with a long parallel-sided abdomen; ventral scopa black. 36
Small bees, length 9 mm. or less; ventral scopa pale. 37
- 36 Male with face largely silvery from appressed hairs, and clypeus shallowly emarginate; females with eyes slightly converging above. **Monumetha** (21)
Male unknown; females with eyes diverging above; clypeus with a strong, smooth and shining, longitudinal median ridge. **Osmia hypocrita** Ckll.
- 37 Base of first abdominal segment ordinary, rounded, with a narrow longitudinal sulcus. 38
Base of first abdominal segment with a flattened or concave smooth shining plate or basin, the edge of which is well defined. 39
- 38 Male with flagellum greatly thickened, with a terminal hook. **Alcidamea** (20)
Male with flagellum long and filiform (genus not yet found in Colorado). **Robertsonella** (22)
- 39 More coarsely punctured; end of first recurrent nervure not more (usually less) distant from base of second submarginal cell than half length of first transverso-cubital; male abdomen not ending in four teeth. 40
Less coarsely punctured; end of the first recurrent nervure more distant from base of second submarginal cell than half length of first transverso-cubital; male abdomen ending in four teeth. 41
- 40 Anterior legs largely red (Boulder, at flowers of *Monarda*, July 16, 1908, W. P. Cockerell). - **Heriades asteris** Ckll.
Legs all black (Boulder, July, W. P. Cockerell, S. A. Rohwer). **Heriades carinatus** Cresson (24)
- 41 Larger, anterior wings $4\frac{1}{2}$ to $5\frac{1}{2}$ mm. (Boulder, August 28, Rohwer; Rifle, Colo., July, Rohwer; usually taken at flowers of *Grindelia*). **Ashmeadiella denticulata** Cresson (23)
Smaller, anterior wings about 3 mm. (Boulder, May, Rohwer). **Ashmeadiella prosopidis** Ckll

A further table of male *Ashmeadiella* is given:

- Larger, 7 mm. long or a little over. denticulata Cresson
 Small, less than 6 mm. long. 1
- 1 Tegulae reddish testaceous; length about 5½ mm. wings quite clear; abdominal teeth red-tipped, middle ones much longer than broad (Rifle, Colo.). aridula Ckll.
- Tegulae dark. 2
- 2 Length nearly 6 mm., tegulae shining piceous; middle abdominal teeth much longer than broad (Florissant, Colo., at flowers of *Senecio cymbalarioides*, June 29, Rohwer). cactorum Ckll.
- Length about 4½ to 5 mm.; middle teeth of abdomen short. prosopidis Ckll.
- 42 Marginal cell very long, almost reaching apex of wing; eyes hairy. Apis (26)
 Marginal cell with tip distant from apex of wing. 43
- 43 First recurrent nervure meeting first transverso-cubital; large bee with bright fulvous hair on thorax and base of abdomen, and abdomen with white hair bands (New Mexico). Caupolicana yarrowi Cresson
- First recurrent nervure not meeting first transverso-cubital. 44
- 44 First discoidal cell much longer than marginal cell. 45
 First discoidal cell not as long or scarcely longer than marginal cell. 53
- 45 Marginal cell short, not half the length of the first discoidal, and not or scarcely extending beyond apex of third submarginal cell; parasitic bees. 46
 Marginal cell at least half the length of the first discoidal and extending more or less beyond the third submarginal. 47
- 46 Hair of thorax abundant and erect; first abdominal segment with hair like thorax; rest of abdomen black, in one species with light spots. Bombomelecta (46)
 Hair of thorax appressed; first abdominal segment black and bare at base; abdomen with interrupted light bands. Pseudomelecta
- 47 Third submarginal cell subquadrate, not or hardly narrower above than beneath; marginal cell obtuse at tip; hairy bees; the clypeus partly or wholly yellow or white in the male; tongue very long. 48
 Third submarginal cell narrower above than beneath, or when not so, insect without erect hair; marginal cell extending far beyond apex of third submarginal cell. 49
- 48 Mandibles tridentate; apex of female abdomen with orange red hair; species nesting in dead wood. Clisodon terminalis Cresson (27)
 Mandibles simple or bidentate; species nesting in banks. Anthophora (47)
- 49 Robust, pollen-collecting bees, the thorax with abundant erect hairs; similar to *Anthophora* but first recurrent nervure reaching apical corner of second submarginal cell. Emphoropsis (28)
 Parasitic bees, less hairy, and with conspicuous pale markings, or when these are absent, insect red. 50
- 50 Abdomen black with conspicuous pale bands due to appressed scale-like hair. 51
 Abdomen with tegumentary bands (nearly always yellow) or spots, or red without markings. 52

- 51 Fifth segment of female abdomen with large patch of silvery hair. **Triepeolus** (29)
 Silvery patch reduced to a lunule or band; insects usually smaller. **Epeolus**
- 52 Mandibles simple. **Nomada**¹ (30)
 Mandibles with an inner tooth. **Nomada**, subgenus **Gnathias** (30)
- 53 Head and thorax with metallic colors, blue or green. 54
 Head and thorax black, rarely with some red, never metallic. 58
- 54 Head and thorax brilliant emerald green or blue green; basal nervure strongly arched.
 55
 Head and thorax dark green or blue. 56
- 55 First recurrent nervure joining second submarginal cell near middle; male abdomen
 banded with yellow and black, female abdomen green or black. **Agapostemon** (34)
 First recurrent nervure reaching apex, or very near apex, of second submarginal cell;
 abdomen green like thorax in both sexes. **Augochlora** (32)
- 56 Small, shining dark green bees; first recurrent nervure joining second submarginal
 cell near apex; tongue long; face in female with an ivory spot, in male with a large
 tri-lobed ivory mark. **Ceratina** (33)
 Minutely punctured bees, with the head and thorax hairy; face without light markings
 in either sex or (in male *Halictus*) with a small light band on clypeus; tongue
 dagger-like. 57
- 57 Basal nervure strongly arched; abdomen often not metallic. **Halictus** (35)
 Basal nervure hardly arched. **Andrena** (36, 49)
- 58 Mouth-parts greatly elongated, held under the body when at rest, like the beak of an
 Hemipteron (Denver, Colo.). **Melitoma grisella** Ckll. and Porter
 Mouth folded and concealed when at rest. 59
- 59 Marginal cell sharply truncate at tip, the lower corner with an appendicular nervure;
 face largely pale yellow. **Protandrena**
 Marginal cell not thus truncate, but obtuse or pointed. 60
- 60 Face more or less yellow or white, the color tegumentary; basal nervure nearly
 straight.² 61
 Face without light tegumentary color. 65
- 61 Stigma nearly always well developed; male antennae not greatly elongated; tongue
 dagger-like. **Andrena** (36, 49)
 Stigma little developed; male antennae usually elongated; tongue very long, linear.
 62
- 62 Antennae very long, black; maxillary palpi 6-jointed. **Tetralonia** (37)
 Antennae usually shorter, though long, and more or less reddish (in a few species black);
 maxillary palpi with less than six joints. 63
- 63 Maxillary palpi 4-jointed (many species). **Melissodes**³ (38, 48)
 Maxillary palpi 5-jointed. 64
- 64 Maxillary palpi comparatively long and slender. **Xenoglossa** (39)
 Maxillary palpi shorter (genus not known in Boulder County). **Xenoglossodes** (40)

¹ For a table of Rocky Mountain *Nomada*, see *Bulletin* 94, *Colorado Agricultural Experiment Station*.

² Some male Halictines have yellow on clypeus; these have the basal nervure strongly arched. If bright green with yellow and black abdomen they are *Agapostemon*; if dark green, *Halictus*.

³ *Anthedon*, a genus scarcely distinct from *Melissodes*, has the male antennae with the last joint elongated. The scopa of the female is simple.

- 65 Abdomen wholly or largely red. 66
Abdomen not red, or if at all red, that color due to hair. 67
- 66 Basal nervure strongly arched; small species. *Sphecodes* (43)
Basal nervure nearly straight. *Andrena* (36, 49)
- 67 Second recurrent nervure with a strong double curve, approaching an S-shape; tongue short and emarginate; hairy bees. *Colletes* (42)
Second recurrent nervure not so formed, straight or with a single gentle curve. 68
- 68 Lower inner corner of second submarginal cell produced; large hairy bees with very long tongue. 69
Second submarginal cell not thus formed. 70
- 69 Females with shining pollen-collecting surfaces on hind legs. *Bombus* (45)
Females with unmodified hind legs, covered with hair. *Psithyrus* (44)
- 70 Basal nervure strongly arched; stigma well developed; tongue dagger-like. *Halictus* (35)
Basal nervure straight or almost. 71
- 71 Hind margins of abdominal segments with beautiful pale greenish tegumentary bands, the other parts of the abdomen strongly punctured (Boulder). *Nomia universitatis* Ckll.
Abdomen without greenish bands. 72
- 72 Stigma well developed; apex of marginal cell on or very near costal margin. 73
Stigma little developed; apex of marginal cell away from costal margin. 74
- 73 Posterior face of metathorax flat, shining, sharply separated from basal area, which is strongly rugose; tibiae and tarsi bright ferruginous; hind tibiae of male deformed, wings yellowish, apical margin strongly dusky (Boulder, September 16, Rohwer; Denver, at flowers of *Solidago*, August 24, Mrs. C. Bennett). *Nomia bakeri* Ckll.
Posterior face of metathorax not thus differentiated; tibiae of male not deformed. *Andrena* (36, 49)
- 74 Vertex smooth, brilliantly shining; form compact; male abdomen bidentate at extreme apex. *Diadasia* (41)
Vertex less shining; abdomen otherwise formed at apex. 75
- 75 Maxillary palpi 6-jointed; scopa of hind legs in female simple. *Tetralonia* (37)
Maxillary palpi 4-jointed; scopa plumose. *Melissodes* (38, 48)
Maxillary palpi 5-jointed. *Xenoglossa* (39) and *Xenoglossodes* (40)
The following table separates a series of females of the last two genera:
Abdomen red; large robust species (New Mexico). *Xenoglossa patricia* Ckll.
- Abdomen not red. 1
1 Lower margin of clypeus broadly yellow (New Mexico). *Xenoglossodes gutierreziae* Ckll.
Clypeus without yellow. 2
2 Flagellum bright ferruginous beneath, except at base (Roswell, New Mexico). *Xenoglossodes excurrens* Ckll.

Flagellum dark, sometimes obscure reddish.

3

- 3 Abdomen beyond the second segment covered with ochreous tomentum, not at all banded (New Mexico).

Xenoglossodes imitatrix Ckll. and Porter

Abdomen beyond the second segment banded.

4

- 4 Larger and more robust, breadth of thorax about 5 mm.; thorax covered above with fulvous hair; hind basitarsus thinly haired, but the hairs long.

Xenoglossa pruinosa Say

Smaller and narrower, breadth of thorax 4 mm. or less; hair of thorax above not brilliantly colored; hind basitarsus more densely hairy.

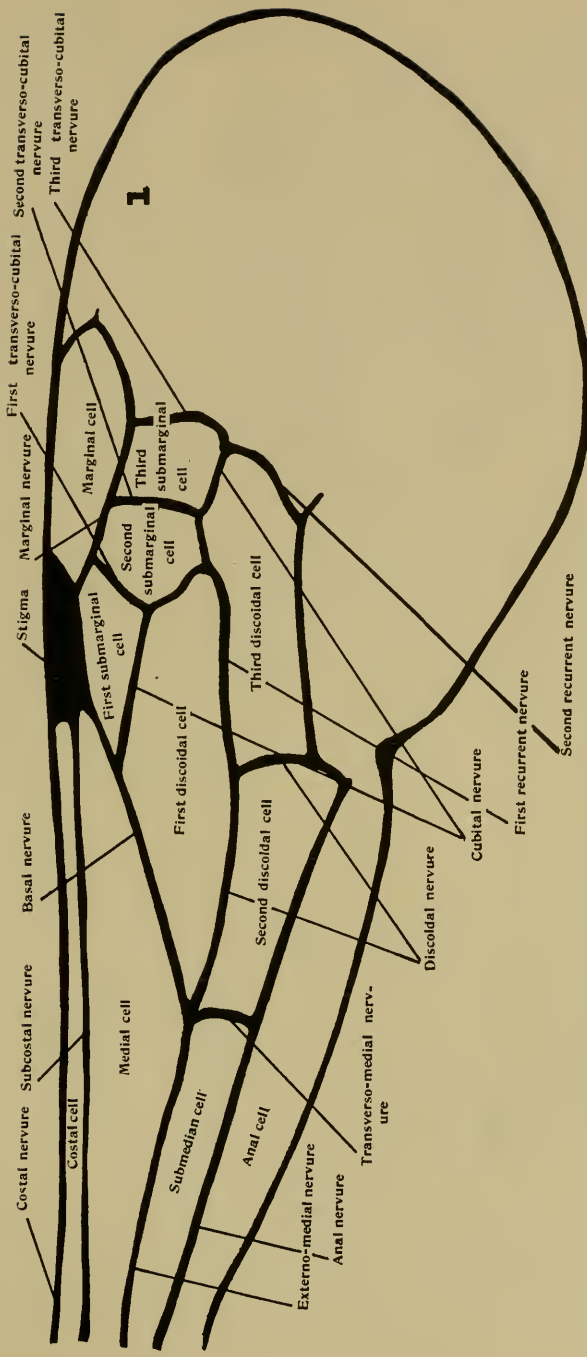
5

- 5 Middle third of fifth abdominal segment with the hair dark chocolate brown (New Mexico).

Xenoglossodes lippiae Ckll.

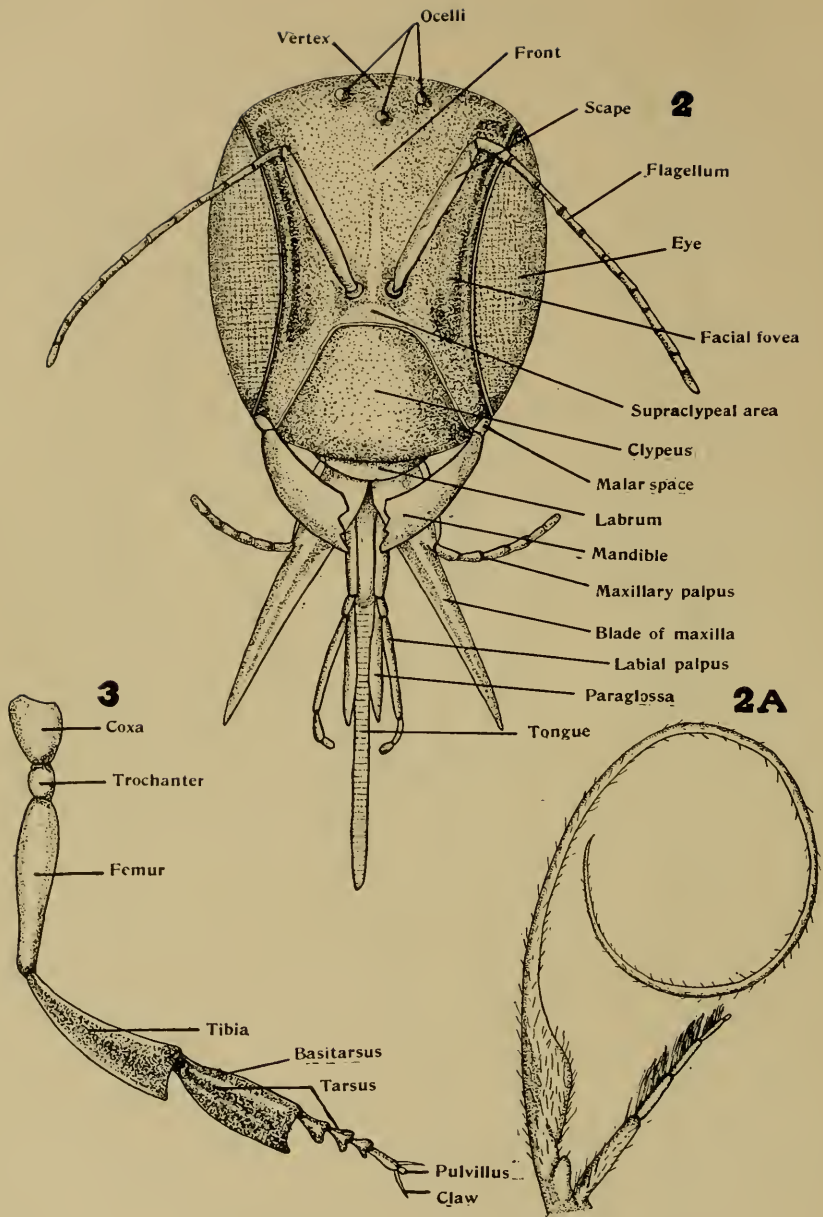
Middle of fifth abdominal segment with the hair wholly pale (Raton, New Mexico).

Xenoglossodes neotomae Ckll.



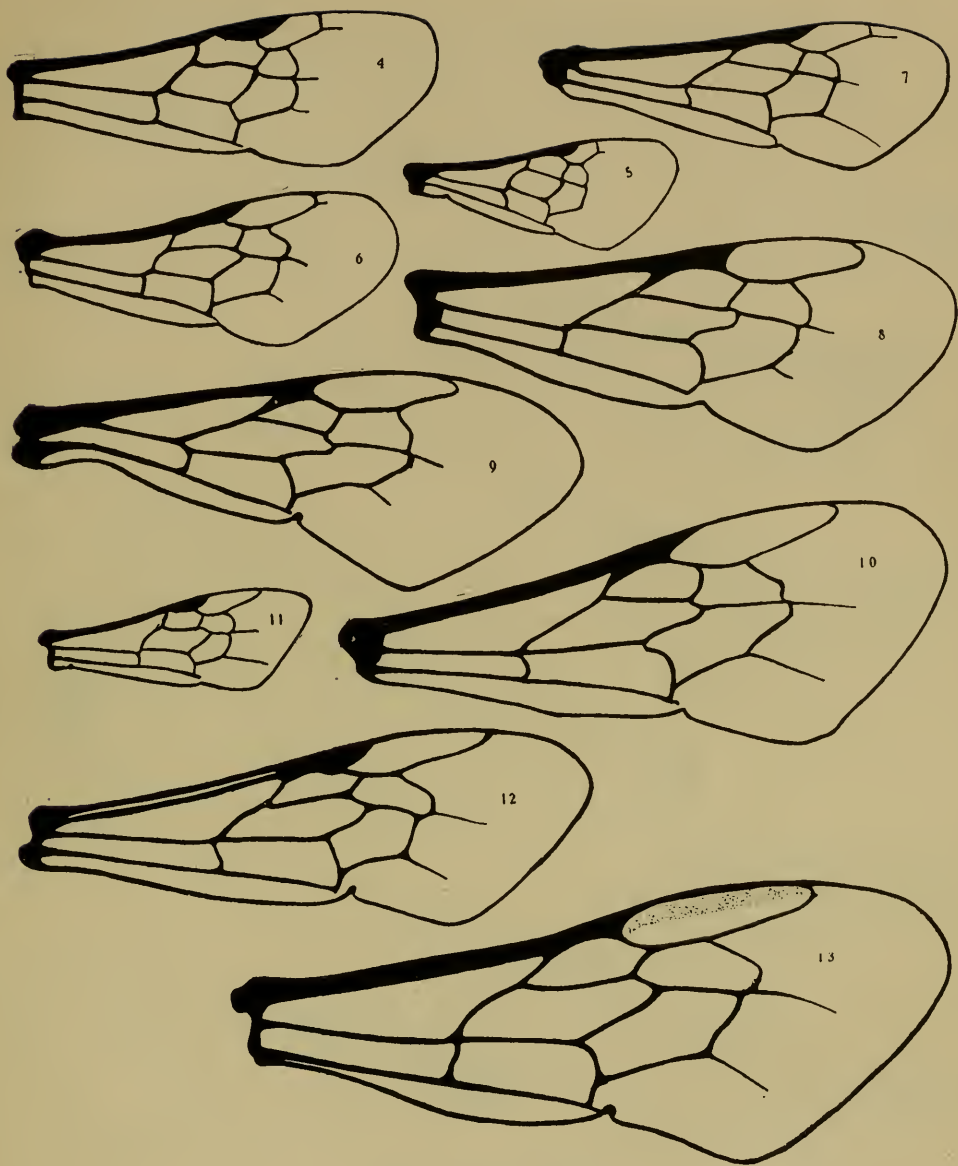
ROCKY MOUNTAIN BEES

FIG. 1.—Anterior wing of *Clisodon terminalis* showing the nomenclature of the cells and nerves. In the following plates the costal cell is not shown in all the figures. It is, however, always present.



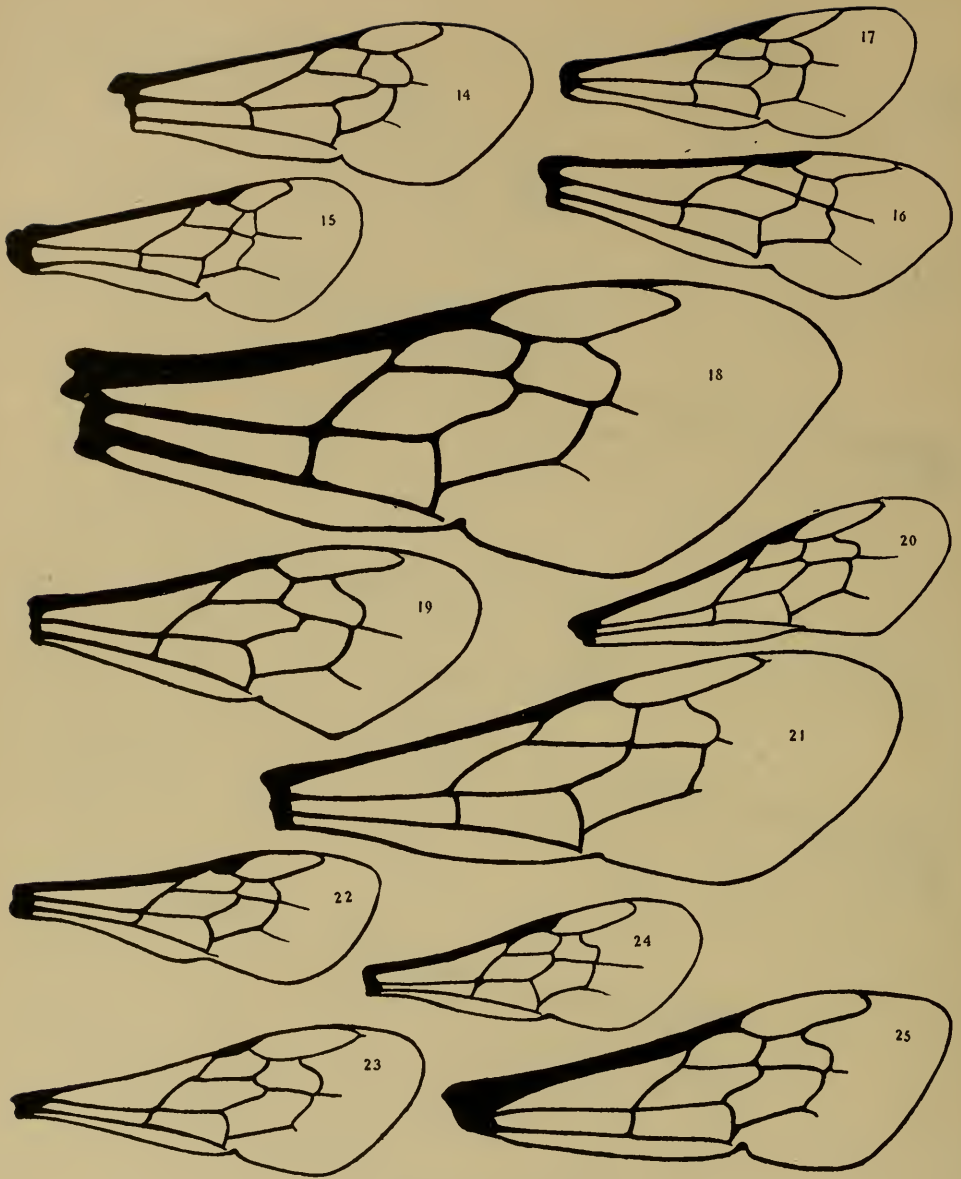
ROCKY MOUNTAIN BEES

FIG. 2.—Ideal head of bee showing structural details. FIG. 2A.—Maxilla and maxillary palpus of *Melitoma grisella*; FIG. 3.—Hind leg of bee showing nomenclature of parts.



ROCKY MOUNTAIN BEES

FIG. 4.—*Perdita lacteipennis*; FIG. 5.—*Perdita ignota*; FIG. 6.—*Spinoliella australior*;
 FIG. 7.—*Panurginus cressoniellus*; FIG. 8.—*Coelioxys sayi*; FIG. 9.—*Anthidium emarginatum*;
 FIG. 10.—*Dianthidium parvum*, FIG. 11.—*Dialictus anomalus*; FIG. 12.—*Dianthidium nothocalaidis*;
 FIG. 13.—*Osmia propinqua*.



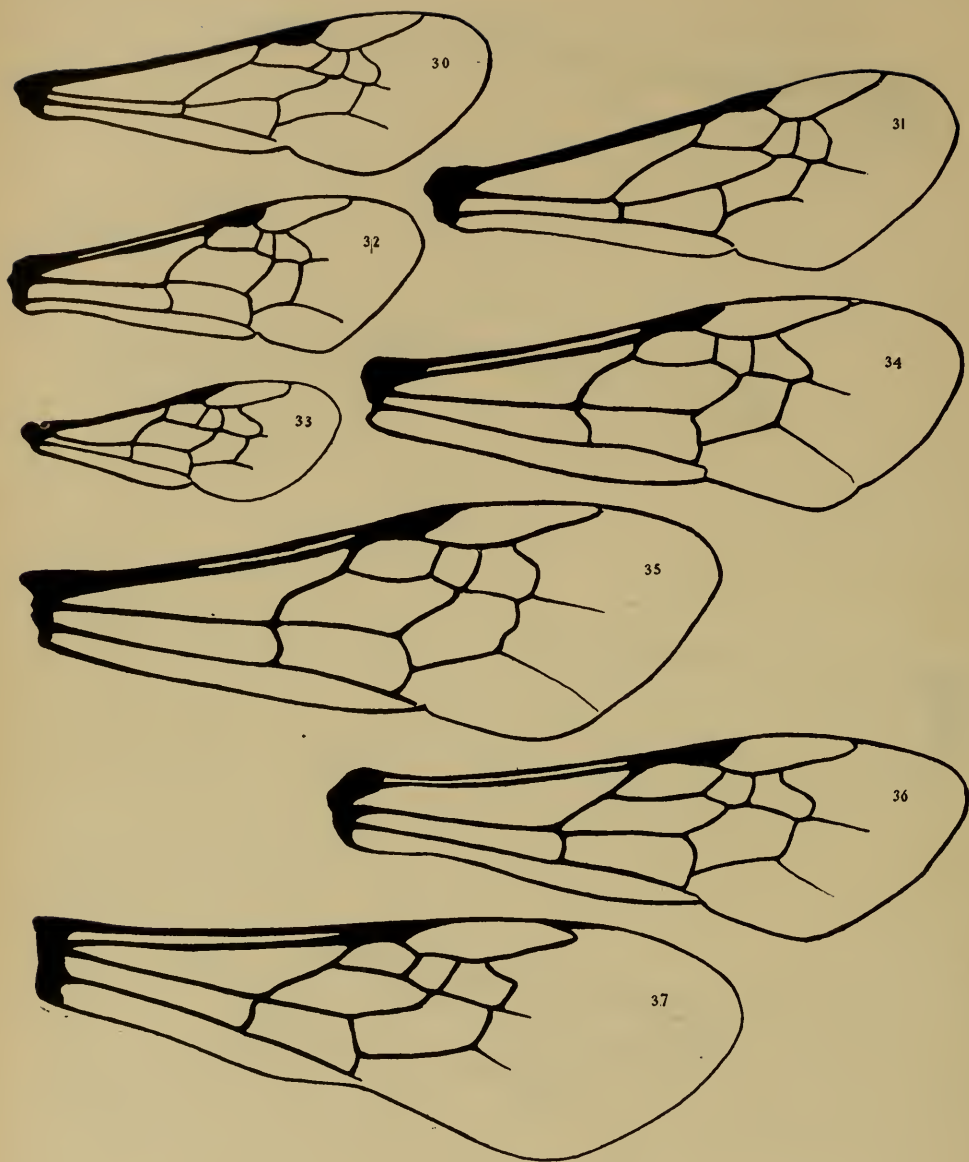
ROCKY MOUNTAIN BEES

FIG. 14.—*Phileremus americanus*; FIG. 15.—*Neopasites heliopsis*; FIG. 16.—*Prosopis variifrons*; FIG. 17.—*Halictoides harveyi*; FIG. 18.—*Lithurgus apicalis*; FIG. 19.—*Titusella pronitens*; FIG. 20.—*Alcidamea simplex*; FIG. 21.—*Monumetha albifrons*; FIG. 22.—*Robertsonella gleasoni*; FIG. 23.—*Ashmeadiella denticulata*; FIG. 24.—*Heriades carinatus*; FIG. 25.—*Megachile brevis*.



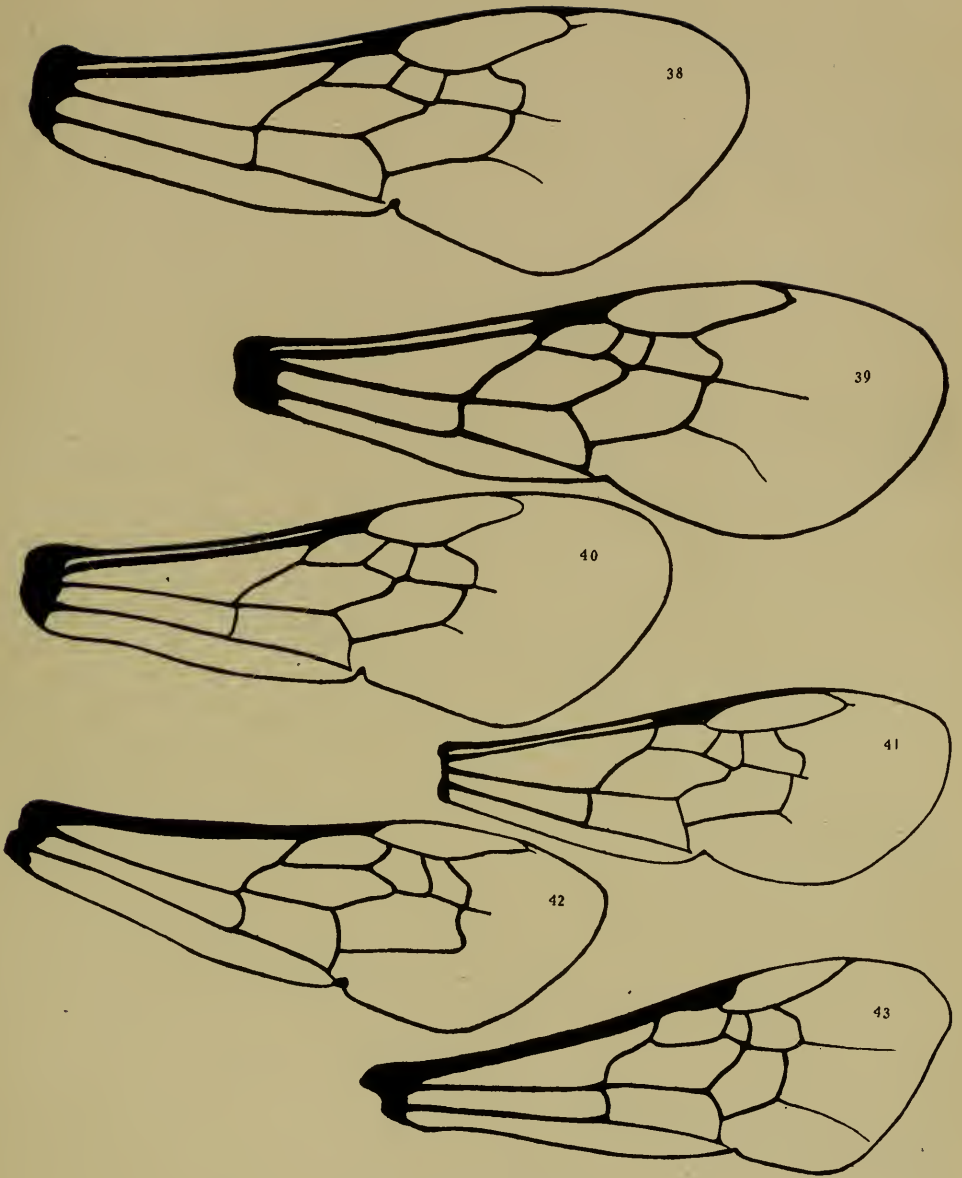
ROCKY MOUNTAIN BEES

FIG. 26.—*Apis mellifera*; FIG. 27.—*Clisodon terminalis*; FIG. 28.—*Emphoropsis johnsoni*; FIG. 29.—*Triepeolus helianthi*.



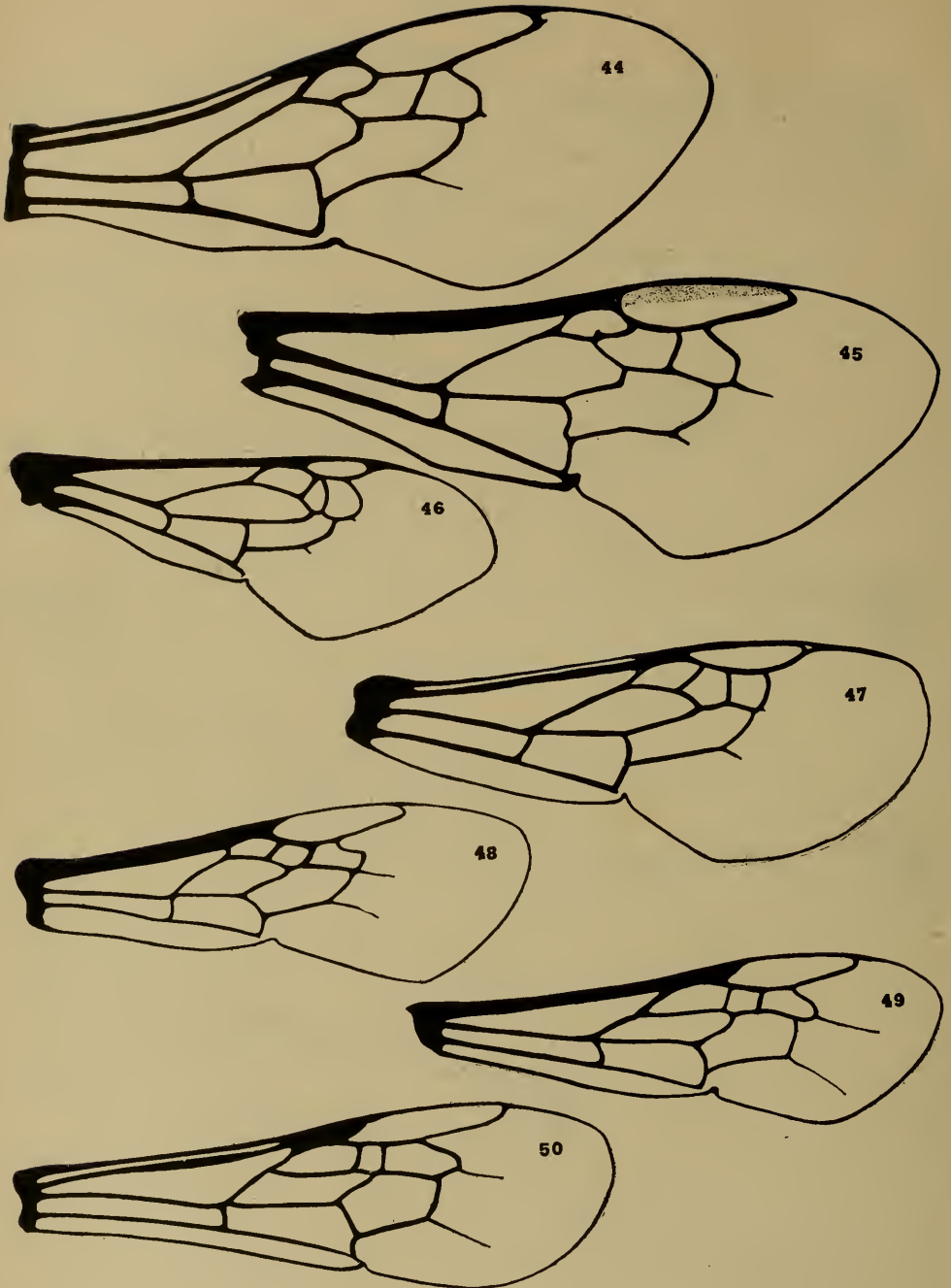
ROCKY MOUNTAIN BEES

FIG. 30.—*Nomada vexator*; FIG. 31.—*Nomada* (Gnathias) *lepida*; FIG. 32.—*Augochlora confusa*; FIG. 33.—*Ceratina nanula*; FIG. 34.—*Agapostemon texanus*; FIG. 35.—*Halictus lerouxii*; FIG. 36.—*Andrena bridwelli*; FIG. 37.—*Tetralonia edwardsii vagabunda*.



ROCKY MOUNTAIN BEES

FIG. 38.—*Melissodes pallidicincta*; FIG. 39.—*Xenoglossa angelica*; FIG. 40.—*Xenoglossodes imitatrix*; FIG. 41.—*Diadasia diminuta*; FIG. 42.—*Colletes kincaidii*; FIG. 43.—*Sphecodes pecosensis*.



ROCKY MOUNTAIN BEES

FIG. 44.—*Psithyrus insularis*; FIG. 45.—*Bombus huntii*; FIG. 46.—*Bombomelecta fulvida*; FIG. 47.—*Anthophora occidentalis*; FIG. 48.—*Melissodes obliqua*; FIG. 49.—*Andrena argemonis*; FIG. 50.—*Nomia nortoni*.

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CONTENTS

	PAGE
1. PRE-THALESIAN PHILOSOPHY	201
MELANCHTHON F. LIBBY, PH.D. Professor of Philosophy	
2. SEX DIFFERENCES AND VARIABILITY IN COLOR PERCEPTION	207
V. A. C. HENMON, PH.D. Professor of Psychology	
3. INTRODUCTION TO THE STUDY OF THE ANTS OF NORTHERN COLORADO	215
W. W. ROBBINS, M.A. Instructor in Biology	
4. REMARKS ON SOME NORTHERN COLORADO PLANT COM- MUNITIES WITH SPECIAL REFERENCE TO BOULDER PARK (TOLLAND, COLO.)	223
FRANCIS RAMALEY, PH.D. Professor of Biology	
5. NOTES ON THE FLOW OF WATER IN IRRIGATION DITCHES	237
CLEMENT C. WILLIAMS, C.E. Associate Professor of Civil Engineering	
6. ALPHABETICAL INDEX	249



PRE-THALESIAN PHILOSOPHY

BY MELANCHTHON F. LIBBY

Teil I, Abteilung V, of Teubner's admirable series, "Die Kultur der Gegenwart," is the great collaboration entitled *Allgemeine Geschichte der Philosophie*. This great history (541 large pages) is the result of the combined work of Wundt, Aldenberg, Goldzicher, Grube, Tetsujiro Inouye, von Arnim, Baeumker and Windelband. Those who had believed that no better histories of philosophy than those of Ueberweg, Windelband and Erdmann could be produced, may have to revise their opinion. And the advance is not in scholarship so much as in a certain freshness and originality of handling which quite unsettle the usual notion that subjects grow pedantic under prolonged research.

The whole work is an inspiration to a teacher of college philosophy. Not only is the modern *Weltanschauung* handled with genuine freedom and vigor, but also the Greek masters are treated with rare sympathy and infectious culture. The work is an exposition of the broad and genial spirit of present-day philosophy, and is a reproof to works like those of Allen Upward, and other critics, who value themselves a good deal because they ignore such works as these (and the writings of Paulsen, Fischer, Höffding and Eucken, to name a few), while they repeat stale *facetiæ* regarding Berkeley and Kant. How would any specialist like to defend textbooks in his subject of from one hundred fifty to three hundred years of age: textbooks for example in geology or biology?

However, the purpose of this paper is not to review this welcome work, but merely to emphasize one division of it, namely, the thirty-page chapter with which it opens, and which has for its subject, "The Beginnings of Philosophy and the Philosophy of Primitive Peoples." This brilliant essay is by Wundt, and is not the least of his many contributions. This history so far as I know is the first to give a serious treatment of pre-Thalesian philosophy. In the earlier works it is not to be looked for of course. From Negel to Erdmann there is no curiosity manifested concerning the source of the interests that grew into philosophy. But

even in works which have appeared since the great masterpiece of Tylor one seeks in vain for a first chapter even remotely resembling this by Wundt. The twenty-five works most used, in general and in ancient philosophy, show at best a vague tendency to trace the Ionian movement to the Greek myths and the sayings of the sages. Most of them begin with the definition of the subject and proceed from that to Thales. There is no doubt that many teachers, since the publication of Tylor's work, have been beginning their courses with some notes on anthropology or ethnopsychology, and therefore this departure will be well received. It seems most desirable that in so markedly psychogenetic an age every textbook dealing with the development of philosophy should begin with primitive culture. Wundt declares that for the province of primitive psychology the work of Tylor (1873), as a first comprehensive collection of the phenomena of the doctrine of the soul among various races, has been epoch-making in the last degree. He speaks with enthusiasm of Fraser's *The Golden Bough* (1900), and these works together with Wundt's *Völkerpsychologie* and Sumner's *Folkways* make a good background for this first chapter of history.

The subject is fascinating for its own sake, and for its bearing upon psychology, and the science of religion. Recent works on this latter subject show how profoundly the facts of animism have shaken the ontological assumptions of the crude materialistic dogmatism of the 1870's. The insistent repetition of the greatest of all the truths of psychic origins, namely, that the world was *beseelt*, that the water Thales wrote of was not H₂O at all, but the same that gleams in trout pools for small boys, has gone far to shake the alleged view of common-sense, that is, modern common-sense, that "chalk is chalk and cheese is cheese." When every textbook in the history of philosophy begins with a chapter of this kind we shall be on the highway to a more hopeful conclusion.

Wundt of course anticipates the objections of students, who will argue that in this chapter he steps over the border of philosophy into the dim and mysterious forest of the early myths. But like most of his readers he is probably not discomposed by this. If he promotes a truer and deeper view of the real development of the subject, Americans at least will not quarrel with him over the arbitrary definitions of words.

He has shown in more than one of his earlier works that no one has seized hold of the essence of the mythopoeic power more convincingly; and he repeats that mythology is the fruitful mother of all the activities of civilized, mental activity. He admits that the tendency to real explanatory work sets in markedly with the school of Miletus; but he sees that there is still much of the matrix about the jewel of science. And then on the other hand, when he turns to the rich masses of primitive wisdom in the folklore of these great collectors how clearly his eye detects the points that are really of philosophical significance. Here we have the clear and piercing insight of this great writer at its brightest and best. He turns lightly away from the jurisprudence, and religion, and government, and manners, and poetry, and military strategy, and other features of the ancient fables, and fixes our minds upon

- 1) the beginnings of logic,
- 2) the beginnings of psychology,
- 3) the beginnings of natural philosophy,
- 4) the beginnings of ethics.

Primitive logic, he writes, knows no abstract ideas, and knows general ideas only in the most limited sense. The pine, the elm, the oak, are known, but not the tree. Knowledge is of concrete and individual character. Primitive thinking is also entirely objective. Savages relate the most atrocious tales of battle and chase, without the least allusion to any feelings on the part of anybody. The verb hardly exists in really primitive tongues; words represent things and their properties; speech is very childlike. *The deepest principle of knowledge is that whatever is given in sense-perception is directly certain just as it is given.* To sense-perceptions we must add some few fantastic ideas based on a long experience of nature. Movements and changes of objects are next in reality to the objects themselves. Out of the very regularity of natural movements and changes springs an interest in irregular happenings, and as these happenings affect the weal and woe of men, the great *why?* of science may be said to be born thereof. Such in briefest outline is this great expert's summary of the tap-root of logic.

Turning to *primitive psychology* he begins by showing that psychic life is nothing separated from the bodily life; both belong together.

Death and dreams give pause to this original unity. Two real things known to sense, the vapor of the breath, and the shadow-picture of dreams, give rise to the idea of a soul. Psychic processes such as perception and feeling have nothing to do with this idea at first. Primitive psychology does not even attempt to explain death and dreams, it is no hypothesis or explanation but a belief about facts. After death the soul remains for a time in the body. This means that survivors cannot at once dissociate the two; "even in our ashes live their wonted fires." But with the decay of the body the soul leaves it in the body of the first worm. Hence arise numerous superstitions about worms and snakes, and much care of the corpse as among the Egyptians. Later the seat of the soul is attributed to different organs of the body, and to the blood and the saliva. This view leads to a sort of sundering of the functions of the soul. The breath belief grows until the soul passes into other animal bodies, especially such as move about quickly and are associated with scenes of death; hence the beliefs in transmigration. The shadow belief is supported by facts of delirium in fevers and ends in ideas of ghosts and demons. Finally these spiritual powers become connected by the mechanism of associative memory with natural objects and forces, and lead to a crude and fantastic philosophy of nature in which we discern the fountain of the great modern philosophies of natural science.

Natural science attempts to spread the great network of human experience, and consequently whoever would seek for its origin in primitive beliefs must seek for the beliefs of primitive peoples concerning the law of causation. German metaphysicians have made much of the universality and necessity of this law and have easily assumed that men have always seen nature under some native conviction that she worked in strict accordance therewith. But this assumption is far from the truth. In the whole matter of perception for example the relation of primitive man to objects of sense was naïve and quite free from the idea that such objects were the causes of experience. He simply experienced, and in no way explained the experience as a phase of the causal nexus. Then again the whole everyday, commonplace process of nature never seemed to him to demand a causal explanation; its very regularity

prevented reflection. It is true that on the poetical and religious side there were many tales about the sun and other great facts of nature, but where these were really from the *earliest* beliefs, they seem to have had no connection with our present subject. On the other hand, it was precisely in the irregular and exceptional occurrences that the germ of scientific wonder is to be sought. The unaccustomed, the disturbing, the fearful, had the power of piercing the primitive mind with curiosity and of stirring the great interrogation. Sickness, especially if sudden and dreadful, and death suggested demonic origins, and thoughts which led to belief in charms and spells and magic, and incantations filled the primitive imagination. Here then in the very beliefs that modern science endeavors to eliminate must we look for the acorn out of which that mighty oak has grown, for it is exactly in primitive magic that the belief in cause and effect had its birth. The first men could conceive of cause only through analogy with their own wills, and all those natural forces which affected their welfare through the immediate environment (the weather, the cattle, the crops, the chase) were conceived of as endowed with wills or spirits, which could be appeased or frightened like themselves. Now some of the forces which seem at first to belong to the neighborhood, such as heat and moisture, have the power of carrying the mind to remoter objects such as the sun and the clouds, and so a philosophy of magical causation gradually grew until it covered the world as it was then known. There sprang up in connection with this fanciful knowledge a parallel, fanciful control, for even among savages knowledge seemed to mean power. The savages of the spirits were met by magical rites and by sacrifices, and out of this struggle emerged a larger view of cause which began to take in the regular as well as the irregular experiences. All these beliefs were closely associated with religious beliefs, but they may be seen also as a dim philosophy or science of the natural forces. When we reach the great theogonies and cosmogonies with which the early world terminates its effort to bear the burden of human thought, there is already established a strong conception of the uniformity of nature and even of the need of wisdom and investigation.

It has long been recognized that the roots of *moral philosophy* are to

be found in the maxims and proverbs of primitive peoples. Wundt advocates a careful and scholarly judgment of the morals of primitive races. He points out that many of their revolting customs are closely associated with their brightest virtues. The drinking of blood and eating of flesh of deceased relatives were connected with reverence for family ties, and condoned by their failure to differentiate men from other animals. Thus even cannibalism must not be measured by our standards. It was not only the seven sages of Greece who coined valuable maxims of conduct. The primitive Australians had many noble sayings about the conduct of life. In the family relations many of the primitive peoples were comparatively above reproach.

The whole subject of primitive philosophizing is shown to be rich in suggestion and there can be no doubt that a study of it will banish many crude ideas. For example Conte's opinion that the human mind developed through the three successive stages of religion, metaphysics and positive science, gets a new reputation in this work, inasmuch as it would rather seem that the three modes of thought have developed together in a sense, though not of course quite *pari passu* in all ages.

SEX DIFFERENCES AND VARIABILITY IN COLOR PERCEPTION

BY V. A. C. HENMON

It is popularly supposed that women possess a more highly developed color sense than men. Women are generally held to be superior both in the recognition of color (the absolute threshold) and in the discrimination of small differences (the differential threshold). Statements to this effect are current in the books which discuss sex differences in mental traits. This superiority of women is variously explained. On the one hand, it is attributed by many to the greater practice in color discrimination acquired by women. The differences would, therefore, be due entirely to individual experience and training. On the other hand, it is held that the difference is congenital and characteristic of sex. On this view it is difficult to see how keenness of color vision could have been a factor in survival and thus be selected, though there is some ground for believing that the more brilliant coloration of the male in some animal forms would be accompanied by a greater discrimination of color in the female. It is still more difficult to suppose that the trait, if it were acquired in individual history, could be transmitted.

The experimental evidence is unsatisfactory and inconclusive. The tests that have been made on the ability of the sexes in the recognition of colors, or the absolute sensitiveness to color, have given conflicting results. *Nichols* (8),¹ in one of the earliest experimental studies, mixed red lead, chromate of lead, chromic oxid and ultra-marine blue with white magnesium carbonate and thus made a graduated series of colors varying in saturation from that of the pure pigments to colors indistinguishable from white. These mixtures were put into small glass phials. Thirty-one men and twenty-three women were asked to select the colors, the phials being mixed in a random order, and arrange them according to hue and saturation. The results showed that men were decidedly more sensitive in the recognition of red, yellow and green, while women

¹ Figures in parentheses refer to the bibliography at the close of the paper.

were more sensitive to blue. *Thompson* (10) mounted 2 mm. squares of red, blue, green and yellow on black and white cards (4×5 inches) and determined the distances at which these colors could be recognized by twenty-five men and twenty-five women. She found that women are in general superior to men in the recognition of colors. In two cases, blue and yellow on the white background, men were superior; in two others, green on white and yellow on black, the results were approximately the same; in the other four combinations women were superior. The superiority of women is most marked in red and in green, while men are superior in yellow. *Nelson* (7), using a Glan spectrophotometer and a Welsbach burner placed .43 meters from the instrument, determined the thresholds for the recognition of the colors, red (657.5 $\mu\mu$ approx.), yellow (580 $\mu\mu$), green (525 $\mu\mu$), blue (470 $\mu\mu$) and violet (445 $\mu\mu$) on twenty men and twenty women. Miss Nelson finds "that women are in general less keen in the recognition of colors" than men. Summarizing the results of her investigation she states that,

taking into account all three methods of calculating the thresholds, the general conclusion would be that men are clearly superior in the recognition of blue; and women are possibly superior in the recognition of yellow.

Miss Thompson's and Miss Nelson's results are thus widely divergent.

Tests on the discrimination of differences in color, the threshold of difference, show greater agreement. Women are in general superior to men in the discriminative sensibility. *Nichols* (8) found that in arranging colors according to saturation women were on the average superior to men in all colors. *Lombroso* (5) found that women were three times as discriminative as men in arranging the Holmgren wools, a fact which he attributes to their work with embroidery. *Luckey* (6), from tests of the indirect color range, was led to doubt the prevailing opinion that women discriminate colors better than men. He found no significant difference in color range or in discriminativeness. *Thompson* (10), in rough tests on accuracy of arrangement of the Holmgren wools according to shade and tint, found women to be very much better in color discrimination than men. The tests were not calculated to determine sex differences with any degree of accuracy.

Tests of the color sense of children have given no definite results.

Gilbert (4) tested New Haven school children between the ages of six and seventeen and found that in arranging ten closely graduated shades of red cloth girls were slightly superior, though the difference was not sufficiently marked to be significant. *Garbini* (3), from experiments on 600 Italian children, concluded that sex differences were not marked in the development of the color sense. In the fourth year the color sense was more developed in boys and in the fifth year more developed in girls. In the fourth, fifth and sixth years the average color sense was better in boys for all colors except blue and violet. *Vitali* (12) found the color sense weaker in girls than in boys. *Luckey* (6) tested 200 children for color range in indirect vision and for discrimination and discovered practically no sex differences.

Of greater interest and importance than the fact of sex differences in color perception is the problem of variability and range. Biologists have found much evidence in support of Darwin's conclusion that there is a "greater general variability in the male sex." *Ellis* (2) regards the greater variability of the male as one of the fundamental sex differences and a fact of the greatest significance. *Pearson* (9) claims to have "laid the axe to the root of the pseudoscientific superstition of the greater variability of the male," but his argument and evidence are unconvincing. Investigations (11), unfortunately very limited in number, have shown that this variational tendency holds of mental traits as well as of bodily characteristics, except during the period of puberty when girls appear to be more variable than boys. The problem is one of great importance for, if the fact of greater deviation of the male from the average is established, we should expect to find in any trait some men who are better than any woman, as well as some men who are worse than any woman—a matter of considerable theoretical and practical significance.

In color perception there is evidence of the greater variability of men, on the one hand, in the much greater frequency of color-blindness in men than in women, and on the other hand, in the fact that the greatest colorists among painters have been men. There is but little experimental evidence. *Nichols* (8), in the study reported above, notes that while women are on the average superior in arranging all colors according to saturation the two nearest approaches to accuracy were by men.

EXPERIMENTS ON ADULTS

The problem of this investigation was twofold: to measure sex differences and to determine the variability and range in color perception. The study was made primarily to secure evidence on variability.

The method employed was as follows: A series of fifty reds was prepared by mixing the best English vermilion and chrome yellow pigments with gum arabic. For the first color a mixture of forty grams of vermilion was made and painted on an eggshell card board, 6×6 inches. For each succeeding step in the series one-fourth of a gram of chrome yellow was added to the mixture and similar cards prepared. The result was a very satisfactory color series, covering purposely a small range, with a view to eliminating in the test, so far as possible, the factor of brightness.¹

For the purpose of determining the correlation between discriminativeness to light and color a series of fifty grays, ranging from the white of the paper used to a mean gray, was also prepared.

From the colors and grays obtained, squares 3×3 inches were mounted on playing cards, cut so that the colors or grays might in the experiment be placed side by side. Thirty-five men and thirty-five women students were asked to make the arrangements. Forty-five minutes were given for the reds and fifteen minutes for the grays. The tests were taken in a room with a north exposure giving a uniform light.

The method of calculating the results consisted in determining the average of the errors made in placing each of the colors, an error of one place counting one, two places two, etc. The average error of displacement, the mean variation, coefficient of variation and the median of displacement are indicated in the following table.

TABLE I

	Number of Cases	Average Displacement	M.V.	Coeff. of Variation	Median
Men.....	35	6.0	2.1	35%	5.4
Women.....	35	5.3	1.5	28%	5.1

¹ It had been my plan to make similar series of blues, greens and yellows, but the difficulty of preparing satisfactory series with mineral pigments led to its abandonment after numerous fruitless trials.

The results show that in the discrimination of reds the women are superior to the men. The average number of displacements for men of 6.0 and for women of 5.3, with probable errors of 0.30 and 0.21, respectively, indicate a significant superiority in women. The median value shows a less marked difference, due to the fact of several widely

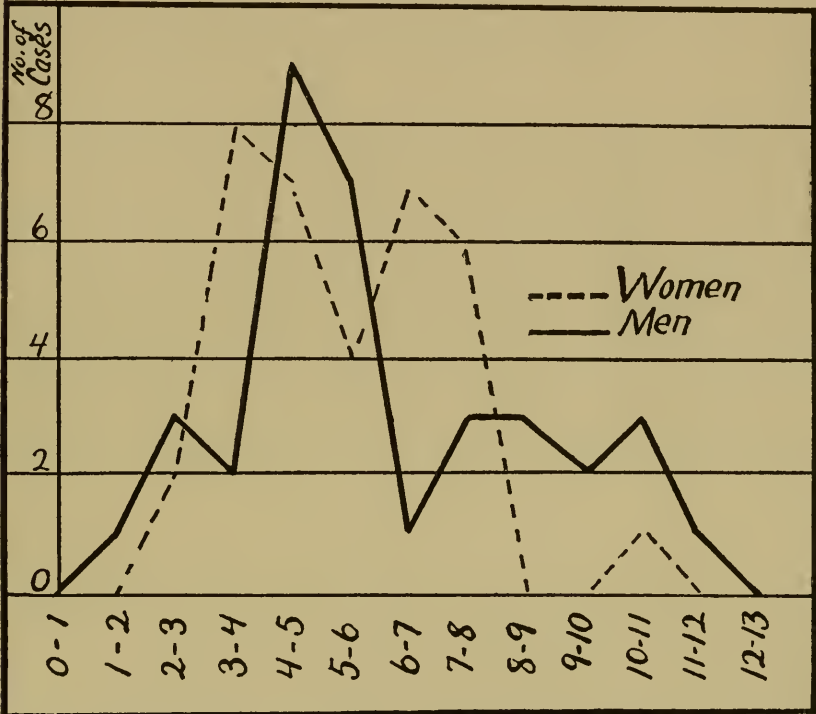


FIG. 1.—DISTRIBUTION OF ERRORS IN COLOR TESTS showing greater range and variability in men.

divergent records in the men. In variability the men are markedly more variable than women as is indicated by the mean variation of 2.1 in men and 1.5 in women and the coefficient of variability of 35 per cent and 28 per cent. The probable errors of the mean variations are 0.21 for men and 0.15 for women. In range the records of men run from 1.4 to 11.1 and for women from 2.1 to 10.2.

Fig. 1 gives the distribution of errors in the test, the abscissae repre-

senting the average error of displacement and the ordinates the number of cases.

In the discrimination of the grays the results are as indicated in the following table:

TABLE II

	Number of Cases	Average Displacement	M.V.	Coeff. of Variation	Median
Men.....	28	2.1	0.48	23 ⁰⁷ %	1.9
Women.....	35	1.5	0.44	28 ⁰⁷ %	1.6

Women are here, as in the colors, decidedly superior to the men, the average displacements being 2.1 and 1.5. In the variability the difference is insignificant, the coefficients of variation showing a somewhat greater variability in women. In range, men run from an average error of displacement of 1.2 to 3.9, and women from 0.4 to 2.7.

The experiments on discriminative sensibility to the grays were primarily made to determine the correlation between ability in discriminating colors and grays. The number of cases is too small, however, to determine the amount of correlation with a high degree of validity but the Pearson coefficient of correlation¹ is given for what it is worth.

$$\begin{aligned} \text{Men} & +0.67 \\ \text{Women} & +0.30 \end{aligned}$$

There is evidently a high correlation between discriminative sensibility in the colors and the grays. This may point to a genuine relationship between the two abilities or it may be, and doubtless is partly, a correlation in conscientiousness in making the experiments. In all group tests this is no doubt a factor in determining the amount of correlation and one which cannot well be measured or allowed for. It is of course possible that there is a close relationship between discriminative sensibility in different sense departments but it could be satisfactorily measured only on the assumption that equal interest and effort were displayed in the tests from which the correlation is determined.

¹ Calculated by the formula $\sqrt{\frac{\sum xy}{n\sigma^2\sigma^2}}$, $\sum xy$ being the sum of the products of the deviations and $n\sigma^2\sigma^2$ the product of the number of cases and the standard deviations of the two abilities. A correlation +1.00 would mean perfect positive correlation, 0.00, the absence of correlation and -1.00 perfect inverse correlation.

EXPERIMENTS ON SCHOOL CHILDREN¹

Experiments were also made on 100 school children, 50 boys and 50 girls, ranging in age from 11 years to 15 years. The age distribution was as follows: 7 eleven-year-olds, 29 twelve-year-olds, 32 thirteen-year-olds, 28 fourteen-year-olds and 4 fifteen-year-olds. For the tests fifteen colors from the set used in the above experiments were selected, every third being taken till the fifteen were secured.

The results were as follows:

TABLE III

	Number of Cases	Average Displacement	M.V.	Coeff. of Variation	Median
Boys.....	50	1.88	0.73	39%	1.80
Girls.....	50	1.87	0.78	42%	1.87

There is practically no difference in the sexes in the perception of differences in the reds. The girls show a slightly greater variability

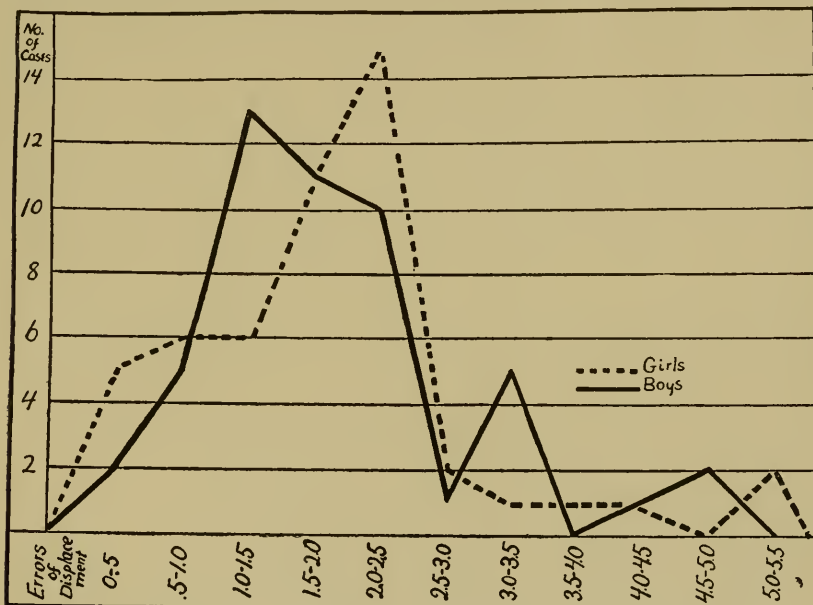


FIG. 2.—DISTRIBUTION OF ERRORS IN COLOR TESTS OF SCHOOL CHILDREN.

¹ I am indebted to Miss Mary M. Hughes of the University Hill School for securing these results.

though the differences are not significant. This accords with results obtained in other tests which show a greater variability in girls at the two years nearest the age of puberty for girls. In range the average errors for boys run from 0 to 4.9 and in girls from 0 to 5.4.

Fig. 2 gives the distribution of the errors, the abscissae representing the average error of displacement and the ordinates the number of cases.

CONCLUSIONS

The conclusions which seem warranted by this study are:

1. That women are decidedly superior to men in discriminative sensibility to reds and grays.
2. That men show a decidedly greater variability in discriminating reds.
3. That in school children between the ages of eleven and fifteen years there is no significant difference in perception of differences in red and that the variability and range is slightly greater in girls.

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AN INTRODUCTION TO THE STUDY OF THE ANTS OF NORTHERN COLORADO

BY WILFRED W. ROBBINS

The present paper is offered as a beginning in the study of Colorado ants. Myrmecologists have collected and studied in the state, but the results of their work are scattered. No systematic work has been done upon the composition of our ant fauna, upon problems of distribution, habits, etc. Professor William M. Wheeler is intending to publish soon a list of the ants of Colorado, including all the material which he has collected or received from different parts of the state. Such a list is much needed and coming from the pen of Professor Wheeler will be highly valuable and indispensable.

The following enumeration of species occurring in northern Colorado is necessarily incomplete, but it presents something upon which to build. It is hoped that the artificial key will facilitate the labor of identification of genera and enable those who are beginning the study to find their way more easily. Keys for the separation of species are not available.¹

ARTIFICIAL KEY TO GENERA OF ANTS KNOWN TO OCCUR IN NORTHERN COLORADO

(For the identification of workers)²

1. Pedicel of abdomen one-jointed (fig. 1).
 - A. Abdomen proper constricted between segments 1 and 2 (fig. 2a). Ponera
 - B. Abdomen proper not constricted between segments 1 and 2.
 1. Antennae 9-jointed; small red ants. Brachymyrmex
 2. Antennae 12-jointed.
 - a. Large, slowly moving ants, usually black; frontal carinae sinuous, in form of S. Camponotus
 - b. Not as above.
 - a) Ocelli absent or indistinct.
 - a) Basal prolongation of abdomen covering the pedicel (fig. 2e); small black ants. Tapinoma
 - b) Basal prolongation of abdomen not covering the pedicel (fig. 1).
 - aa) Anal aperture circular (fig. 3g); clypeus trapeziform; legs short. Lasius
 - bb) Anal aperture in form of transverse slit (fig. 3h); clypeus triangular; legs long. Iridomyrmex

¹ In his recently published book, *Ants*, Professor William M. Wheeler gives a key to the subfamilies, genera and subgenera of the North American Formicidae for the identification of workers.

² Wheeler has described a new inquiline genus *Symphoidole* based upon specimens from Boulder and Colorado Springs. The description is based upon males and females, the workers being apparently non-existent. The key in hand being based upon workers, the above genus is not included.

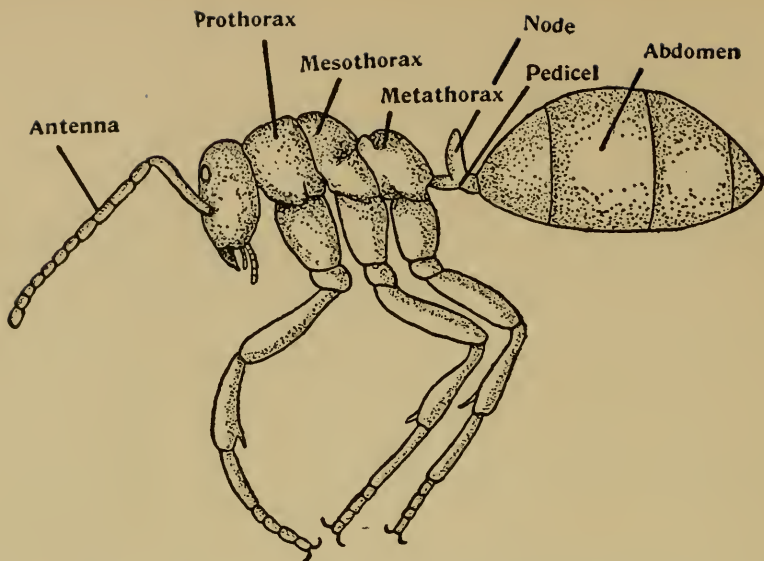


FIG. 1.—SIDE VIEW OF *Formica ruja* L., SUBSP. *rubiginosa* EMERY.

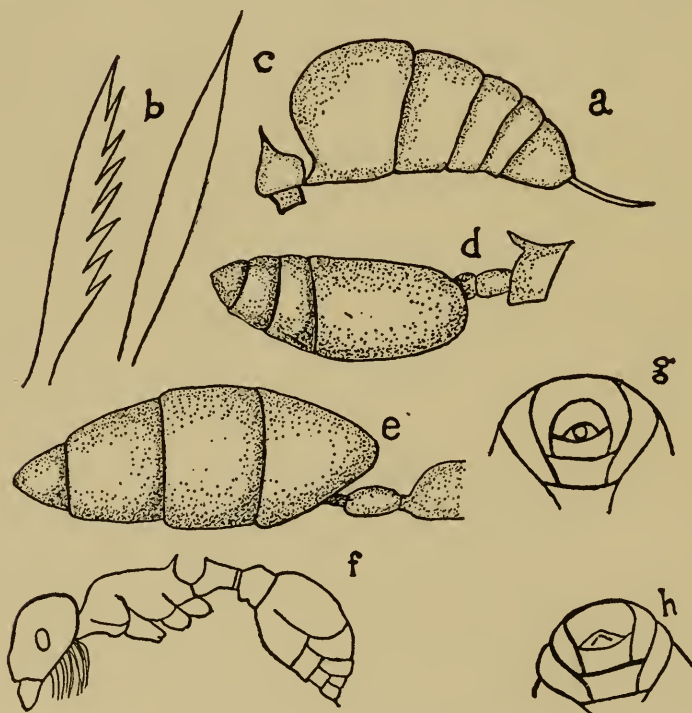


FIG. 2.—DETAILS OF STRUCTURE IN VARIOUS SPECIES.

a. Abdomen of worker of *Ponera* showing constriction between first and second segments; b. Toothed spur on posterior tibia of *Myrmica*; c. Simple spur on posterior tibia of *Stenammas*; d. Showing attachment of pedicel to dorsal surface of abdomen in *Cremastogaster lineolata* Say; e. Abdomen and pedicel of *Tapinoma sessile* Say; f. Side view of *Pogonomyrmex occidentalis* Cresson; note beard on the head; g. Circular anal aperture of *Lasius*; h. Slit-like anal aperture of *Iridomyrmex*.

- b) Ocelli distinct.
- a) Metathorax with obtuse spine. Dorymyrmex
- b) Metathorax without spine. Formica
- aa) Node of pedicel flat; frontal carinae diverging posteriorly (fig. 3a). Formica
- bb) Node of pedicel rounded; frontal carinae nearly parallel. Myrmecocystus

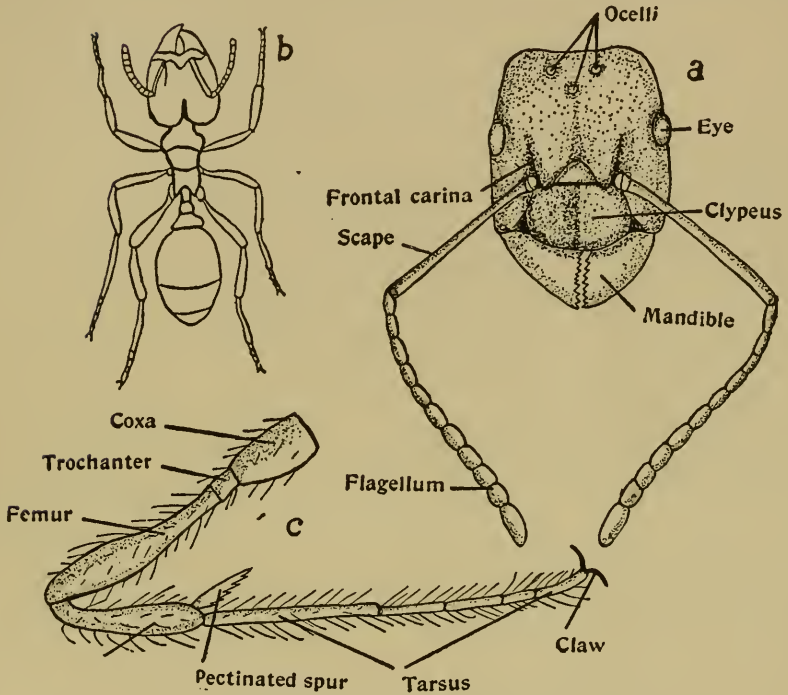


FIG. 3.—DETAILS OF STRUCTURE IN VARIOUS SPECIES.

a. Front view of head of *Formica rufa* L., subsp. *rubiginosa* Emery; b. *Pheidole* sp., soldier; note disproportionately large head as compared with the rest of the body; c. Posterior leg of *Myrmica scabrenodis* Nyl.

II. Pedicel of abdomen 2-jointed (fig. 2f).

- A. Pedicel attached to dorsal surface of abdomen (fig. 2d). Cremastogaster
- B. Pedicel attached to middle or to ventral surface of abdomen (fig. 1). Solenopsis
- 1. Antennae 10-jointed; very small ants. Pogonomyrmex
- 2. Antennae 11- or 12-jointed.
- a. Beard present on head (fig. 2f).
- b. Beard not present on head.
- a) Some individuals of colony with head disproportionately large as compared with body (fig. 3b). Pheidole

- b) Not as above.
- a) Tibiae of posterior legs with simple spur (fig. 2c); spines of metathorax short; clypeus flat.
- aa) Maxillary palpi 4-jointed; flagellum without distinct club gradually thickened from base to apex. **Aphaenogaster**
- bb) Maxillary palpi 5-jointed; flagellum with a distinctly 3-jointed club. **Leptothorax**
- b) Tibiae of posterior legs with pectinated (toothed) spur (fig. 2b); spines of metathorax long; clypeus convex. **Myrmica**

PRELIMINARY LIST OF SPECIES OF ANTS IN NORTHERN COLORADO²

SUBFAMILY: MYRMICINAE

- Aphaenogaster julva* Roger (Boulder).
Cremastogaster lineolata Say (Boulder).
Leptothorax acervorum Mayr., var. *yankee* Emery (Boulder).
Leptothorax curvispinosus Mayr., subsp. *annectens* Wheeler (Boulder).
Leptothorax muscorum Nyl., var. *sordidus* Wheeler (Boulder).
Myrmica brevinodis Emery, var. (Boulder, Meeker).
Myrmica scabrinodis Nyl., var. (Tolland, Boulder).
Myrmica rubra sulcinodoides Emery (Boulder, Ward).
Myrmica rubra L., subsp. *brevinodis* Emery (Boulder, Meeker).
Myrmica rubra L., subsp. *scabrinodis* Nyl., var. (Tolland, Boulder).
Myrmica rubra L., var. *sulcinodoides* Emery (Boulder, Ward).
Myrmica mutica Emery.³
Pheidole pilifera Roger, subsp. *coloradensis* Emery (Boulder).
Pheidole ceres Wheeler (Boulder).
Pheidole vinelandica Forel (Boulder).
Pogonomyrmex occidentalis Cresson (Meeker, Boulder, Rifle Gap, New Castle).
Solenopsis molesta Say (Boulder).
Sympheidole elecebra Wheeler (Boulder).

SUBFAMILY: DOLICHODERINAE

- Dorymyrmex pyramicus* Roger (New Castle).
Dorymyrmex pyramicus Roger, var. *niger* Pergande (Boulder).
Iridomyrmex analis André (Boulder).
Tapinoma sessile Say (Tolland, Boulder).

SUBFAMILY: CAMPONOTINAE

- Brachymyrmex heeri* Forel, subsp. *depilis* Emery (Boulder).
Camponotus levigatus F. Smith (Meeker).
Camponotus herculeanus L., var. *whymperi* Forel (Tolland).
Camponotus maculatus Fabr., subsp. *vicinus* Mayr., var. *nitidiventris* Emery (Boulder).
Formica crinita Wheeler (Boulder).
Formica fusca L., var. *argentata* Wheeler (Jenny Lake, Tolland).
Formica munda Wheeler (Boulder).

¹ This species may be confounded with the workers of *Pheidole*, or *vice versa*, their habits are different, however. *Leptothorax* spp. form much smaller colonies, often not more than 25 or 50 individuals; also their motion is much more rapid than that of *Pheidole* spp. The thorax of *Pheidole* is strongly constricted between the meso- and metathorax; in *Leptothorax* it is but slightly or not at all constricted.

² In nearly every case the species listed have been determined by Professor William M. Wheeler, the American authority on Formicidae.

³ This species has not been found in northern Colorado but according to Professor Wheeler should occur here, since it is so abundant in other localities of Colorado, Idaho and even in British Columbia.

- Formica rufa* L., subsp. *ruginosa* Emery (Pine Cliff, Boulder).
Formica rufa L., subsp. *obscuripes* Forel (Tolland, Boulder).
Formica rufa L., subsp. *integra* Nyl., var. *coloradensis* Wheeler (Tolland).
Formica rufa L., subsp. *obscuripes* Forel var. *melanotica* Emery (Boulder).
Formica subpolita Mayr., var. (New Castle, Boulder, Tolland).
Formica pergandei Emery (Boulder).
Formica sanguinea Latr., subsp. *subnuda* Emery (Tolland).
Formica sanguinea Latr., subsp. *rubicunda* Emery (Tolland).
Formica fusca L., var. between var. *subsericea* Say and var. *argentata* Wheeler (Pine Cliff, Tolland).
Formica ciliata Mayr. (Boulder).
Formica microgyna Wheeler (Boulder).
Formica pallidefulva Latr., subsp. *schaufussi* Mayr. (Boulder).
Formica pallidefulva Latr., subsp. *nitidiventris* Emery (Boulder).
Formica fusca L., var. *neorufibarbis* Emery (Long's Peak, 12,500 ft.).
Formica fusca, var. *neoclara* Emery (Boulder).
Formica oreas Wheeler (Boulder).
Lasius (Acanthomyops) interjectus Mayr., small var. ? (Boulder).
Lasius niger L., var. *americanus* Emery (Boulder).
Lasius umbratus Nyl., subsp. *speculiventris* Emery (Boulder).
Lasius niger L., var. *neoniger* Emery (Boulder).
Myrmecocystus melliger Forel, subsp. *mendax* Wheeler (Denver).

SUBFAMILY: PONERINAE

Ponera opaciceps Mayr. (Boulder).

NOTES ON DISTRIBUTION AND HABITS

Cremastogaster lineolata Say. This species is the only one of the genus *Cremastogaster* which ranges over the whole United States. It extends up to an altitude of 7,000 feet in Colorado. The other species are confined to the southern and southwestern states. The workers are often seen attending masses of coccids or aphids on plants, feeding on the "honey dew" which these insects give off. It has the habit of building on the twigs of plants high above ground "tents" over colonies of these coccids or aphids; hence they are called the "tent-building ants." These tents are enclosures made of agglutinated earth or vegetable matter and often show wonderful workmanship. The workers have a disagreeable odor.

Dorymyrmex pyramicus Roger. This species occurs at altitudes below 6,000 feet. It lives almost always in barren soil.

Dorymyrmex pyramicus Roger, var. *niger* Pergande. This small black ant makes diminutive circular hills in barren soil, $\frac{1}{2}$ inch high and about 2 inches in diameter. It is common at lower altitudes in Colorado.

Formica crinata Wheeler. The nests are from $\frac{1}{2}$ -1 foot high and are often constructed of conifer needles.

Formica fusca L., var. between *subsericea* Say var. and *argentata* Wheeler var. This is a very rapidly moving ant. It is easily disturbed and excited, even by scraping the feet near the nest.

Formica rufa L., subsp. *obscuripes* Forel. I have seen this subspecies attending aphids on the leaves of aspen.

Formica fusca L., var. *argentata* Wheeler, occurs at considerable elevations, probably above 7,500 feet in northern Colorado.

Formica sanguinea Latr., subsp. *rubicunda*. A number of individuals found at Tolland in a damp cellar had chewed the wood of shelves into a fine sawdust for their nest. They are usually found with slaves. The enslaved individuals belong to other species of *Formica*.

Formica munda Wheeler. This species is abundant at altitudes below 7,000 feet. The nests are usually in grassy places.

Lasius niger L., var. *americanus* Emery. Ants of this variety occur from low to high altitudes in Colorado. They often build tents low to the ground around the stems of plants and like *Cremastogaster lineolata*, keep captive there a number of aphids or coccids, chiefly mealy-bugs. In overturning a stone, under which there is a colony of these ants, the workers are seen to seize the mealy-bugs and take them away out of sight. In many of the middle-western states, these ants do considerable damage in corn fields, by their habit of cultivating the root-aphids of the corn.

Leptothorax spp. This is a very widespread group of small ants. They form very small colonies, often not more than 25 to 50 individuals. The nests are small and may be in the ground, between stones or within the tissues of plants. Abandoned galls are often utilized for their nests.

Myrmecocystus melliger mendax Wheeler. Members of this genus are confined almost entirely to the warmer and arid countries. They are abundant in Colorado as far north as Colorado Springs. As far as known, only one colony has been seen in northern Colorado and that by Wheeler in Denver. This is the farthest point north to which any of the *Myrmecocysti* have been traced. The *Myrmecocysti* or Honey Ants are interesting from the fact that certain workers, "repletes," store large quantities of honey within their abdomen. The size of the abdomen becomes prodigious and the individual is barely able to walk.

Myrmica rubra brevinodis Emery. In the neighborhood of Boulder, Professor T. D. A. Cockerell has noticed that masses of these ants are attracted to the sunflower plant and are killed by the sap which exudes from broken branches. It illustrates a case of maladjustment in the relations of ants to plants.

Pheidole ceres Wheeler. In colonies of this genus may be found four different forms: large-headed soldiers, much smaller and very numerous workers, winged males and winged females. *Pheidole ceres* is a harvesting ant which lives upon seeds stored up in the nest. The nests are found in sunny places under stones. This species is rather common at altitudes from 5,000 feet to 9,000 feet.

Sympheidole elecebra Wheeler. These ants are inquiline, that is, they live with other ants. They have been reported by Wheeler as occurring in the nests of *Pheidole ceres*, which they much resemble. Unlike *Pheidole*, the workers are non-existent.

Pogonomyrmex occidentalis Cresson is very abundant at elevations between 6,000 feet and 7,000 feet. It is called the "Agricultural" or "Mound-building Prairie Ant." It is distributed over the western plains of the United States, living in large colonies in gravel-covered mounds. The ants remove all the vegetation away from about the nest, so that the mound stands in a cleared, circular space. These mounds, located in the center of cleared, circular areas, are conspicuous objects in many parts of the great plains.

Solenopsis molesta Say. This small, yellow species has a wide geographic range. It often forms compound nests with larger ants. Living in the nests of other species, the

individuals prey on larvae and pupae and eat the food of their hosts. They often live with species of *Myrmica*, *Formica*, *Lasius* and *Stenamma*. In the eastern states *Solenopsis molesta* has become a house-pest.

Tapinoma sessile Say. This small, black ant has a wide altitudinal range, being found from 5,000 feet to 10,500 feet. The workers have a peculiar rancid-butter odor.

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REMARKS ON SOME NORTHERN COLORADO
PLANT COMMUNITIES WITH SPECIAL
REFERENCE TO BOULDER PARK
(TOLLAND, COLORADO)¹

BY FRANCIS RAMALEY

Classification of Plant Communities.—The term *community* is applied to an assemblage of plants occupying some definite area. If the area thus covered be of wide extent the community is known as a *formation*. Communities of smaller area, or perhaps characterized by certain dominant species, are called *associations*. Thus in the foothill region of northern Colorado there is a *coniferous forest formation* made up of rock pines and Douglas spruces: the former in drier places, the latter occupying shaded areas where there is more moisture. Here then the coniferous forest formation of the foothills embraces a *rock pine association* and a *Douglas spruce association*. In like manner a thicket formation may embrace an alder association, a willow association, etc. In the grassland formation of our plains area there may be distinguished a *grama grass association*, *buffalo grass association* and others.

Within the limits of an association subsidiary groups of vegetation are known as *societies*. Assemblages of mountain daisies (*Erigeron*) form *Erigeron societies* in the *Bouteloua association* of the *plains grassland formation*.

Formations may well be given names which indicate at once the general character of the vegetation, as: *streamside deciduous forest formation*, *plains grassland formation*, *alpine fell-field formation*, etc. On the other hand, it is customary to name associations and societies for one or more species which are dominant and give character to the community: *limber pine association*, *Trifolium society*, *Elymus condensatus society*.

Somewhat at variance with the systematic classification here outlined is the general American usage according to which almost any assemblage

¹ Adapted with certain changes from notes of a course of four lectures given at the University of Colorado Mountain Laboratory at Tolland, Colo., in July, 1909.

of plants is denoted a "formation." In this case "general formation" may be used to indicate the larger aggregations and "formation" be applied to the *associations* defined in the previous paragraphs.

In any region it is possible to make the associations many or few, since classification depends largely upon individual judgment. No two botanists are likely to agree in the method of naming or in the number or limits of associations or other communities.

On account of the altitude of Boulder Park¹ (about 9,000 ft.) with its consequent low summer temperature (the July mean about 56 degrees F.) the plant species are largely different from those of the plains area at Denver or Boulder. Hence the plant communities are also different. The student who wishes to make a comparison with other localities in the state may consult some of the papers noted in the reading list.

Life Zones.—Within a distance of ten miles of Boulder Park four life zones, as listed below, are represented. The names here employed are such as are readily understood and are the ones used in Europe. Zoölogists in America have another set of terms, originally proposed by Dr. C. Hart Merriam, and these are given below in parentheses.

1. *Foothill zone* (apparently the upper "Transition" of Merriam). At Rollinsville and farther down the valley this zone is locally represented on south exposures of hillsides even where the general vegetation is that of the montane zone.
2. *Montane zone* (apparently the "Canadian"). Boulder Park and the adjacent hills all belong to this zone. It is to be noted, however, that local areas in shaded gulches have a sub-alpine flora.
3. *Sub-alpine zone* ("Hudsonian" and part of "Arctic-Alpine"). The district around Jenny Lake and, in general, wherever Engelmann spruce forests form the prevailing vegetation may be classed as sub-alpine.
4. *Alpine zone* (part of the "Arctic-Alpine"). Rollins Pass (Corona, Colo.) and all other points above timberline are in this zone.

Forest, Scrub and Grassland.—For our purposes we may consider any assemblage of trees, or of shrubs taller than a man's head, as forming a *forest*. The forest may be close or open, may be of wide extent or may consist merely of a fringe of trees along a stream. A *scrub* consists of

¹ The term *park* is used in the western United States to designate a broad mountain valley, treeless or nearly so, which is surrounded by wooded hills. Such valleys are often the result of the action of glaciers in modifying the form of an original V-shaped gulch. Sometimes they are due to stream erosion cutting back and forth in an area softer than that up stream or down stream. Often the parks are old lake beds. As a rule there are two or more streams uniting somewhere in a park and all the water flows out of the park through a single narrow canyon.

shrubs, while *grassland* is made up of herbaceous plants among which there need be no true grasses at all. Coniferous forests of pines are drought-resisting or *xerophytic*, while alders, willows and aspens which require a moderate amount of water may be described as *mesophytic*. Engelmann spruces live in rather moist soil but it is cold and often "sour," hence the habitat is physiologically dry because these conditions retard absorption of water by roots. Spruce forests may on this account be called xerophytic, although various authors—the present writer included—have at times spoken of spruce forests as mesophytic.

List of Plant Communities.—The following list will serve for reference in the later discussion. It is not intended as complete but to be suggestive.

BOULDER PARK AND VICINITY

1. *Lodgepole Pine Forest*—*Pinus murrayana* "Oreg. Com."
2. *Limber Pine Forest*—*Pinus flexilis* James.
3. *Engelmann Spruce Forest*—*Picea engelmanni* (Parry) Engelm.
4. *Aspen Forest*—*Populus tremuloides* Michx.
5. *Willow and Alder Thicket*—*Salix chlorophylla* Anders., *Salix brachycarpa* Nutt., *Alnus tenuifolia* Nutt.
6. *Rock Pine Forest*—*Pinus scopulorum* (Engelm.) Lemmon.
7. *Willow, Birch and Honeysuckle Scrub*—*Salix* spp., *Betula glandulosa* Michx., *Lonicera involucrata* Banks.
8. *Potentilla Scrub*—*Potentilla fruticosa* Linn. (*Dasiphora fruticosa* Rydb.).
9. *Sage-Brush Scrub*—*Artemisia tridentata* Nutt. (perhaps *Artemisia arbuscula* Nutt.).
10. *Swamp or Moor*—*Carex* spp.
11. *Meadow* (moderately moist grassland).
12. *Dry Grassland*.
13. *Gravel Slide*.
14. *Sand Bank and Sand Bar*.
15. *Aquatic Vegetation*.
16. *Vegetation of Roadsides and Waste Places* (ruderal vegetation).
17. *Forest Undergrowths*.

AT ROLLINS PASS (CORONA, COLO.)

1. *Pond Vegetation*—*Potamogeton*, various algae, etc.
2. *Scrub*—*Salix* spp.
3. *Swamp or Moor*—*Carex* spp., *Caltha*, *Trollius*, *Elephantella*.
4. *Meadow*—*Rydbergia*, *Campanula*, *Trifolium*, *Mertensia*, *Sieversia*, *Poa* spp.
5. *Rock Desert Vegetation* ("Dry Tundra")—*Eritrichium*, *Silene*, *Tetraneuris*, *Selaginella*, *Antennaria*, *Artemisia*.

COMMUNITIES AT BOULDER PARK

Forest.—Lodgepole pine forest is the association of the hills around Boulder Park. This forest is invaded sparingly on steep slopes by Engelmann spruce and sub-alpine fir. It is replaced in moist seepage areas and in recently burned-over places by aspens. Where best developed the individual lodgepole pine trees stand close together and there is very little growth on the forest floor.

On dry exposed ridges, such as the top of the "Giant's Ladder" (the hill to the north of the park), an invasion of the lodgepole forest by limber pines takes place, and isolated groups of limber pine trees occur in various dry and windswept stations. Along the railway track east of Tolland there is such a group of trees, also some on Baltimore Ridge to the south and some at the western edge of the park. Limber pine never covers large areas as a pure forest.

Pure Engelmann spruce forest belongs properly to the sub-alpine zone but is found in South Boulder Canyon, north exposure, to the west of the park. It is the usual forest at higher altitudes up to timberline. Engelmann spruces invade old moors or swamps along streams in the sub-alpine zone. They live in cold, wet soil.

Aspen forests in this region are seldom of wide extent except where they occupy areas recently denuded of coniferous trees. The aspen association or society represents a stage in reforestation by conifers. In moist areas around springs or where there is considerable seepage, aspens may maintain themselves for long periods. They tend to form rather permanent groves in the basins of old morainal lakes at high elevations.

Willow and alder thickets are confined to stream banks and wet areas around springs. The face of the mountain (Giant's Ladder) which bounds Boulder Park on the north has very dense willow-alder thickets alternating with groves of aspen.

There is no rock pine forest in the immediate vicinity of Tolland although a few isolated trees are to be found to the east of the alder and willow thickets mentioned in the previous paragraph. A single large tree stands on a south-facing slope at the west end of the park. Typical rock pine forest is to be seen near Rollinsville on hillsides having

a south exposure. At Pine Cliff, still farther down the valley, the rock pine is the general association.

Scrub.—A willow-birch-honeysuckle scrub is present everywhere along streams, lagoons and ponds, usually taking a position slightly back from the water, the intervening space being occupied by a strip of sedge moor. Ponds, as they become filled in through silting and the growth of vegetation, are first occupied by sedges and then by these shrubs which in turn give way to coniferous trees (Engelmann spruces) as the soil moisture becomes diminished. Occasionally aspens become established before the conifers make their appearance but this can only occur where drainage is good and the soil not "sour."

Potentilla scrub is generally quite open, that is the bushes are far apart. Grasses, sedges and flowering herbs occupy the interspaces. As a rule this association occurs in situations slightly drier than where willows are found. In the flatter parts of the park it is followed in time by grassland; on steep hillsides it may give way to aspens or to conifers. This community is always to be thought of as proximate and never ultimate. It is continually being replaced¹ in any one locality by other associations adapted to a more stable habitat. On the other hand, such a community as the lodgepole pine association is an *ultimate* community. It does not become replaced by anything else, for it depends on climatic conditions, which do not change.²

There are some scattered *Potentilla* bushes in certain dry grassland areas of the park. In such situations their presence is to be accounted for on historical grounds. They were present at an earlier period when these particular spots of ground had more moisture and they have not yet been driven out by competition with grasses and other herbs, nor have they died out for lack of water.

Across the park from Tolland on the south-facing hill there is a ridge covered with sage brush (*Artemisia tridentata* or possibly *Artemisia arbuscula*). Although Boulder Park seems very high for such a plant

¹ The replacement of one association by another is known technically as *succession* and furnishes an interesting subject for investigation.

² Naturally when it is stated that any particular type of environment does not change it is meant that change will not occur without profound alterations in climate, and these, as is well known, do not take place except at great intervals, and very slowly

which one would expect to find only on the arid plains, yet such sage brush is found at even higher levels along the line of the Denver, Boulder and Western Railroad near the Bluebird Mine in Boulder County a few miles to the north of Tolland. This particular ridge at Tolland where the sage brush grows is sheltered so that it easily becomes well warmed and also it is quickly drained so that conditions are not very different from what would be found on the "sage flats" along the Arkansas River or elsewhere in the plains region.

Grassland.—Bordering the streams and ponds of Boulder Park there is usually a swampy zone formed by a growth of sedges, marsh grasses and other bog or moor plants. This area is somewhat widened out in some parts of the park especially around Park Lake and in other low-lying situations. Scattered through this bog land there are often clumps of willows which, in places, occupy so much of the ground that a true thicket is produced. In like manner an invasion of *Potentilla* may result in the formation of a *Potentilla* scrub. Along the steep hillside at the north of the park there is some of this moorland¹ which at certain points is giving place to willows and alders, or to aspens; in other places it is passing into meadow or else to dry grassland.

What I have called *meadow* is a dense growth of grasses with some sedges and generally a great abundance of flowering herbs. It is somewhat drier than the moor or *Carex* association but more moist than the dry grassland. It is nearly always present as a distinct horizontal belt or zone all along the bases of the small morainic hills east of Tolland. It forms a like characteristic belt following old shore lines and benches west of town. The meadows of Boulder Park might well be divided into a number of societies, many species of plants being established in particular parts of the meadow best suited to their growth.

In the better-drained portions of the park there is a dry grassland which forms a sparse earth-covering because the looseness of the soil permits rapid drying out. Close grass mat such as seen in the meadow does not exist here but certain sod-forming species of *Carex* produce a rather thin carpet. The soil of the dry grassland is shown by study of samples to have a low moisture content.

¹ The word "moor," although practically unknown in America, is a useful term to apply here in place of "bog" or "swamps" which, to Europeans at least, have other and rather different meanings.

Gravel slide plants are found wherever there is much weathered and disintegrated rock. In the course of time a talus slope may produce enough vegetation to allow an accumulation of soil. Limber pines and lodgepole pines will then find their way into the formation and eventually it becomes converted into a part of the general coniferous forest formation.

The plants of *sand banks* and sand bars along streams are few and far between because of the looseness of the soil and the rapidity with which it dries out. A study of the species which first occupy such situations and the changes of vegetation in any such piece of ground would make an interesting little piece of work.

Aquatic vegetation represented in the ponds and streams of Boulder Park is somewhat varied. It might be classified into formations and associations. The most conspicuous seed plants are species of bur reed (*Sparganium*). Algae are numerous. The student should consult Schimper's *Plant Geography* and Warming's *Ecology of Plants* for detailed accounts of the formations of aquatic plants.

THE ALPINE FORMATIONS AT ROLLINS PASS (CORONA, COLORADO)

Although 20 miles by rail from Tolland the top of the pass is only about 8 miles in a straight line. The elevation is 11,660 feet, the top of the ridge above the railway station about 12,000 feet. A true alpine climate is encountered here as is shown by the United States weather records. The July temperature is about 47 degrees Fahrenheit, or 22 degrees lower than the July mean for Denver. The climate can, of course, be judged very well by the plant population. It appears that a few species found on the high peaks adjacent are here absent but the plant formations and associations are the same as occur on the highest mountains in the vicinity.

Little need be said of the *pond vegetation* of the alpine districts, indeed very little is known about it. There are some algae and a very few seed plants found in the cold waters of the lakes above timberline.

Considerable areas of dense *alpine scrub* formed of willows 2 to 4 feet tall occur on the high ground above Corona Lake and in places throughout the alpine zone. A scrub formation of wind-blown Engelmann

spruces seen here and there in the vicinity of Corona station is best considered a sub-alpine association which has come up the hill from its natural home.

Areas of bog or *moor* are scattered here and there throughout the alpine zone. Everywhere there is slight depth of soil. Low places become wet from the run-off of adjacent elevations. In walking a distance of 100 feet across the alpine "tundra" one may pass through ten or more bog areas alternating with as many bits of meadow or of dry "rock desert." These moors are characterized by species of *Carex*, by *Calltha leptosepala*, *Trollius albiflorus* and *Elephantella* among other species.

Alpine meadows are characterized by a somewhat close vegetation of profusely-flowering low herbs such as clovers, together with some conspicuous taller plants as *Rydbergia*, *Campanula* and *Mertensia*. *Sieversia turbinata* often forms considerable carpets. Like the meadow at Boulder Park this particular formation, or association, changes its appearance much from time to time depending on the flowering of the more conspicuous species.

Much of the vegetation in alpine regions is of the alpine mat type found in what may be called *rock desert* areas (dry tundra.) The substratum is dry because of rapid run-off and slight depth of soil. The characteristic plants have the well-known "alpine" habit with low, matted, much-branched stems and an abundance of flowers. Some of the conspicuous plants are *Silene acaulis*, *Eritrichium argenteum*, *Tetranneuris*, *Selaginella* and *Arenaria*.

GENERAL DISCUSSION OF CONDITIONS AT BOULDER PARK

Subsidiary Species.—The study of the principal and secondary species of different associations I leave to the individual student who has here the opportunity to practice the methods used by professional botanists in carrying on ecological research. It will be necessary at present merely to call attention to a few of the more obvious plant relations and thus point the way for individual work by those who wish to pursue the subject.

Since spring snows in Boulder Park are very deep and lie late in the

year among the trees, it makes the growing season for plants very short except in the treeless portions of the park. In dense forests of lodgepole pine and Engelmann spruce snow lasts until April or May at Tolland, while at higher altitudes, as at Jenny Lake, there may be snow fields many acres in extent as late as the middle of June. The visitor who sees the forest in midsummer may well wonder at the absence of undergrowth if he be not informed as to conditions in the spring months; surely dense shade alone would not account for the paucity of vegetation. In more open forest areas where the sun is able to melt the snow earlier a much richer flora of the forest floor is to be found. Here, in addition to blueberries, which form the main undergrowth in the denser forest, there are roses, junipers, various grasses and different flowering herbs.

The principal and secondary species of the various formations are quite different, as would be expected. Engelmann spruce forests offer soil-moisture conditions intermediate between those of the usual dry coniferous forest and the moister associations of aspen, willow and alder. Hence plants characteristic of these latter formations occasionally find their way as invaders among the spruces but only very few species are able to pass from willow thicket to dry pine forest or *vice versa*.

Most interesting in its composition is the sage-brush scrub, where one may find, as it were, a piece of the foothills or plains transported to this montane situation. The plants which make up this formation are nearly all such as occur more abundantly at lower elevations and here reach their highest altitudinal limit.

Edaphic Considerations.—Climatic conditions are much the same throughout Boulder Park. The writer's observations show an inversion of temperature on still nights which makes the temperature of the lower parts of the park from 2 to 5 degrees F. below that of the ridges. This difference may have some influence on the distribution of trees, especially in the growth of seedlings, but it certainly has very little other effect. It is therefore to edaphic factors that we must look for an explanation of the different plant formations. Under the term "edaphic" we include such features as texture of the soil, chemical composition, moisture content and temperatures below the surface; also slope, direction of exposure and all other non-climatic factors.

The greatest single edaphic factor is soil moisture; its effects are so important that they should be accurately noted. Indeed, differences in soil moisture can be recognized without the use of instruments if we compare such associations as sage-brush scrub, *Potentilla* scrub and willow-birch-honeysuckle scrub. The various grassland associations also show striking differences in soil moisture. Even in a single association, as the meadow, it is evident that the different societies which can be there recognized depend for their existence on differences in the water content of the soil. The tall valerian, the small-flowered, low-growing blue *Pentstemon*, the cream-colored *Pentstemon*, the large-flowered *Erigeron*, all so abundant in the meadow formation, do not grow mixed together but have their own places chiefly determined by the moisture of the soil. An interesting study would be to resolve this one association into its separate societies, following carefully the changes which occur in general appearance from week to week through the season and keeping accurate records of moisture in soil samples taken at stations in the different societies. Other problems connected with other associations will occur to the student as subjects for study.

Tables I and II give records of a few observations on soil temperatures and moisture content at East Lake during the summer of 1909.

TABLE I

SOIL TEMPERATURES AT DEPTH OF 1 FT. AT EAST LAKE, TOLLAND, COLO., DURING THE SUMMER OF 1909 (DEGREES F.)

Day and Hour	Sedge Moor	Willow Scrub	<i>Potentilla</i> Scrub	Meadow	Dry Grassland
June 5, 11 A.M.	52	48	58	58	62
June 24, 10 A.M.	55	55	58	62	64
July 12, 4 P.M.	59	66	71	76	81
Sept. 9, 2 P.M.	54	53	55	56	57
Average	55.0	55.5	60.5	63.0	66.0

Zonation.—An arrangement of plants in zones,¹ or belts, is strikingly illustrated in the vegetation around East Lake near Tolland, and somewhat less well shown at Park Lake. Next to the water is a zone of sedges which is followed by willow-birch-honeysuckle and this,[†] in turn,

¹ The name "circum-area" has been suggested by Professor John W. Harshberger for such "zones" as are here described.

by an open *Potentilla* scrub. Still higher on the west and northwest banks, with decreasing soil moisture follows first a belt of meadow and then the dry grassland of the higher ground. At Park Lake in favorable situations it is possible to recognize these same zones and in the same order: sedge, shrub, *Potentilla*, meadow, dry grassland. Along the south shore of East Lake the following zones occur: sedge, shrub, *Potentilla*, meadow, forest.

TABLE II

SOIL MOISTURE OF SAMPLES TAKEN AT DEPTH OF 1 FT. AT EAST LAKE, TOLLAND, COLO., DURING THE SUMMER OF 1909 (PERCENTAGES)

Day and Hour	Sedge Moor	Willow Scrub	<i>Potentilla</i> Scrub	Meadow	Dry Grassland
June 5, 11 A.M.	60.0	63.0	18.0	17.0	2.0
June 24, 10 A.M.	70.2	58.4	29.0	19.3	3.6
July 12, 4 P.M.	46.8	25.2	19.7	5.7	3.8
Sept. 9, 2 P.M.	40.9	26.0	17.4	14.9	9.8
Average.....	54.5	43.1	21.0	14.2	4.8

A further distinction of zones may be made in many places if attention be given to particular species of, let us say, the dry grassland or the meadow. Frequently the yellow sulphur flower (*Eriogonum umbellatum*) and the cream-colored species (*Eriogonum subalpinum*) grow close together and in parallel zones near the base of a hill. In such cases the yellow species occupies the drier situation. A zone of yarrow (*Achillea lanulosa*) is frequently well marked along highways, as the road between Tolland and Jenny Creek. This is best seen about August 1.

In a visit to true alpine lakes or streams above timberline it will be noted that, as a rule, definite belts of vegetation are not developed, although a certain amount of zonation may be recognized. While sub-alpine ponds generally show a *Carex* and a willow zone, the truly alpine ponds, above timberline, are likely to have only a very imperfectly developed zonation. There may be a mixture of plants of moor, meadow, willow scrub and dry tundra even close to the water's edge and possibly no true belts except along some one small part of the shore. The failure of alpine plants to occur in zones is chiefly due to minor local differences in depth of soil, amount of moisture, presence of large rocks, etc.

Seasonal Aspects.—All of the plant formations show marked changes depending on season. The pre-vernal flora begins to appear about April 15 or May 1. In all except very moist situations *Pulsatilla hirsutissima* is common while *Thlaspi coloradense* is even more abundant. These species are found in moderately dense forest, in forest openings and on the open treeless areas of the park.

Spring may be said to begin May 15, summer about July 1 and autumn September 1 or earlier. Throughout the month of June the flowering plants in blossom are those which at Boulder or Colorado Springs bloom in April and May. Loco weed, *Aragallus lamberti*, blossoms about July 1 and this is one of the first true summer flowers at lower altitudes. Aspens and willows do not leaf out until late in June. On account of this shortness of growing period it is possible to become well acquainted with the flora in six or eight weeks instead of requiring four or five months as in warm temperate regions.

Of the different plant formations change of season most affects the appearance of grassland and thicket. Meadow shows, in striking manner, rapid changes due to the flowering of many conspicuous species in quick succession. Thus, in the meadow north of Park Lake great differences in the vegetation may be noted even from day to day.

A careful study of the succession of plants in time of flowering might well be made in one or more associations. Even the student who does not care to make this a special subject of investigation will find interest in noticing, in the meadow zone at East Lake for example, how Pentstemons give way to Erigerons and these to Campanulas, thus bringing about complete changes in the general aspect of the area.

The Glaciation of Boulder Park.—It is at once evident from the appearance of the park that its present extent and form are largely due to the action of glaciers. The rounded knolls and shallow basins just east of Tolland which give the rolling character to that part of the park are all of glacial origin. Indeed, to one who has become accustomed to the well-drained, non-glaciated stream-cut plains area of Colorado the topographic features here presented seem quite novel. The park is like a small portion of the eastern United States dropped down in the midst of the mountains.

At some time a terminal moraine, crossing the valley a few hundred

feet below Tolland station, caused the formation of a lake which covered all the western part of the park, and it is likely that other morainic lakes of different sizes have existed here at different times. Perched boulders on the steep hillsides both to the south and north show that the glacier was at some time 300 to 400 feet above the present level of the park. The soil of the park is made up largely of glacial drift for the most part very slightly worked over by the action of water.

Boulder Park is, like other broad valleys in Colorado, almost treeless and the absence of trees must be due chiefly to soil conditions. The soil is throughout less well drained and of somewhat finer texture than that of the surrounding hillsides. Hence it is better adapted to the grasses and sedges which now occupy it than it would be to conifers. Again it must be remembered that in comparatively recent times the level parts of the park were covered with ice, long after the adjacent ridges were exposed and had become well clothed with timber. It is possible also that inversion of temperature is a minor factor in shutting out tree growth; for in the early spring, when tree seedlings would be most susceptible to irregularities in the temperature, the nights are undoubtedly colder and the days warmer in the park than on the hillsides.

The driest part of the park, with a soil of loose gravel and boulders, is the ridge where the sage-brush scrub occurs north of Park Lake. Adjacent aspen groves in moister soil occupy depressions between different ridges. Vegetation on the knolls east of the railway station and in the shallow depressions, around East Lake and on the lower slopes of Baltimore Ridge shows everywhere its dependence on physiographic features, and these features are the work of glaciers which came down from the Continental Divide.

To those with some geological training I commend a study of vegetation in the park in relation to geologic history. Particularly interesting are the old lake beds, the sage-brush ridge and the morainic lakes and basins. Teller Lakes and the surrounding ridges offer much material for study.

Summary.—The plant associations of Boulder Park (Tolland, Colo.) belong to the montane life zone. A sub-alpine forest of Engelmann spruce is, however, established on north slopes just above the limit of the park while the rock pine forest of the foothills occurs only a few miles

down the valley. Lodgepole pine forest is the general covering of the surrounding hills, while the level portion of the park is a grassland area. Streams and ponds are generally fringed with a willow-birch-honey-suckle scrub, while alder-willow thickets and aspen groves occupy seepage areas. Moor, meadow and dry grassland cover the more level parts of the park proper. Many different formations and associations can be recognized. Edaphic conditions, seasonal aspects, zonation, principal and secondary species, the effects of glaciation—these have all been touched upon briefly. Attention is called only to more obvious ecological facts. Various problems are suggested for study.

It may be well to note that the present paper is intended primarily for use of students at the University of Colorado Mountain Laboratory.

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- , "Climatology and Vegetation in Colorado," *Botanical Gazette*, Vol. XLIX, pp. 256-280, 1910.
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NOTES ON THE FLOW OF WATER IN IRRIGATION DITCHES

BY CLEMENT C. WILLIAMS

A complete and entirely satisfactory method of determining the flow of water in irrigation ditches has not yet been devised. Galileo once declared that he "found less difficulty in the discovery of the motion of the planets, in spite of their amazing distances, than in investigations of the flow of water in rivers which takes place before my very eyes." He maintained that the laws of falling bodies applied to the flow of streams, and hence the velocity was dependent upon the fall regardless of the length of the channel. Torricelli was the first to discover that the inclination of the stream bed governed the velocity of flow. In the first half of the eighteenth century, Pitot and Bernoulli showed that the rate of flow of streams was dependent upon the cross-section of the channel. About fifty years later, Chezy, a French engineer, developed the familiar formula which bears his name based on the fact that in uniformly flowing streams the accelerating forces are equal to the retarding forces. His formula is

$$V = C\sqrt{R \cdot S}$$

where

V = velocity in feet per second

R = hydraulic radius or mean depth

S = slope

C = a coefficient, which he assumed to be constant.

Hydraulic engineers since that time have accepted Chezy's formula and have devoted their efforts mainly to finding a value of the coefficient C based on the slope, the cross-section and the roughness of the stream bed. Dubuat, Venturi, Coulomb, DeProny, Eytelwein and others have contributed various additions to the science along this line. Darcy in 1857 published the first definite formula, which Bazin, Ganguillet and Kutter modified and gave to the world in the following form, commonly known as Kutter's formula:

$$C = \frac{\frac{1.811}{n} + 41.66 + \frac{.00281}{S}}{1 + \frac{n}{\sqrt{R}} \left(41.66 + \frac{.00281}{S} \right)}$$

where *C*, *R* and *S* are as given above and *n* is a "coefficient of roughness" of the stream bed. Kutter proposed values of *n* for different materials among which were the following:

- (1) Canals in fine gravel *n* = 0.020
- (2) Canals and rivers free from stones and weeds *n* = 0.025
- (3) Canals and rivers in bad order *n* = 0.035

Of all the values which he suggested, these are the only ones that would be applicable to ordinary irrigation ditches. The factor *n* = 0.025 has been very generally used, but some large ditches as well as some smaller ones designed on this basis have given very unsatisfactory velocities, in some instances so swift that the washing was serious and in others so sluggish that silt was deposited and vegetation flourished in the channel.

Several attempts have been made to secure more suitable values of *n*, among which the experiments of P. J. Flynn, C.E., of Denver and those of Professor Samuel Fortier of Bozeman, Montana, stand foremost. The results of the very valuable experiments of the latter are published in *Water Supply and Irrigation Paper No. 43* of the United States Geological Survey. He classified the experiments on canals into eight groups which are briefly tabulated below.

GROUP No. 1

n = 0.0134 to 0.0184

The channels were elliptical in form and had been in use from six to thirty years.

Character of Channel	Dis-charge Sec. Ft.	Area Water Section Sq. Ft.	Mean Vel. Ft./Sec.	Slope	<i>n</i>
Clayey loam, well lined with silt. Good condition. Free from vegetation.....	222.5	62.3	3.62	.00031	.0134
Ditto.....	10.7	10.2	1.04	.00012	.0135
Ditto.....	7.9	3.4	2.33	.00188	.0137
Ditto.....	109.6	46.4	2.36	.00027	.0155
Ditto.....	64.0	31.7	2.02	.00027	.0164
Fine gravel, sides fair condition.....	15.4	10.7	1.44	.00032	.0177
Sides smooth; earth and gravel; no vegetation	45.9	17.8	2.58	.00083	.0184

GROUP No. 2

$$n = 0.0194 \text{ to } 0.0213$$

The cross-sections for this group were lacking in uniformity. The bed was usually of small cobblestones or fine gravel. Some of the ditches had been in use thirty years.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Clayey loam lined with sediment. Footprints of stock. No vegetation.....	2.5	2.2	1.14	.00068	.0194
Compact clay, some rock fragments. One side smooth; willow roots projecting on other side.....	22.3	11.5	1.94	.00062	.0195
Clay covered with fine sand; $\frac{1}{2}$ of perimeter covered with vegetation.....	23.6	21.8	1.08	.00015	.0197
Small pebbles imbedded in sand.....	4.0	4.0	1.00	.00056	.0201
No vegetation. Bottom smooth, composed of fine gravel.....	0.6	1.0	0.54	.00135	.0204
Bed smooth, free from vegetation, composed of clayey loam.....	68.6	32.0	2.14	.00046	.0211
Well-packed coarse gravel, weeds at edge.....	51.4	20.6	2.49	.00077	.0213

GROUP No. 3

$$n = 0.0218 \text{ to } 0.0238$$

The ditches in this group usually were designed for a greater flow than they were carrying at the time of the experiments.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Volume carried was small in proportion to capacity. Clayey loam lined with sediment.....	87.3	58.9	1.48	.00027	.0218
Partly full. Bed composed of well-packed smooth gravel lined with sediment.....	1.55	2.6	0.61	.00040	.0223
One-fourth full. Channel of clay; $\frac{1}{2}$ of perimeter covered with "frog moss".....	32.7	27.5	1.19	.00020	.0224
Well-packed gravel; lined with sediment; no vegetation.....	2.3	3.3	0.71	.00043	.0229
Clayey loam lined with sediment. Some "horse tail moss".....	4.6	3.9	1.19	.00075	.0230
Same as above with no moss.....	7.9	5.7	1.38	.00088	.0230
Partly full. Clayey loam; channel partly stopped with irrigators' dams.....	38.6	38.8	1.01	.00012	.0232
Fine gravel; no vegetation.....	10.0	5.3	1.90	.00175	.0238

GROUP No. 4

 $n = 0.0238$ to 0.0260

The channels of this group were characterized by the gravel and rocks in their beds.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Coarse gravel; edges irregular with some willow roots.....	7.6	2.6	2.93	.00616	.0238
Coarse gravel; smooth, lined with sediment ...	60.2	30.6	1.97	.0006	.0246
Sides uneven; bed covered with coarse flat rocks; no vegetation.....	5.7	3.5	1.61	.0016	.0247
Ditto.....	1.6	1.9	0.84	.0013	.0260

GROUP No. 5

 $n = 0.0293$ to 0.0319

The ditches of this group were in poor condition, as the result of neglect.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Clay; cross-section not uniform; grass along edge.....	8.1	4.8	1.69	.0033	.0293
Ditto.....	7.8	12.8	0.61	.00017	.0295
Narrow boards at sides; bottom coarse gravel ..	1.1	1.4	0.75	.00113	.0310
Bed cobblestones; sides overgrown with alfalfa and weeds.....	2.5	2.8	0.88	.0014	.0319

GROUP No. 6

 $n = 0.0329$ to 0.0365

Channels irregular with rough banks.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Cobblestones covered with silt; edges made irregular by cattle tracks.....	1.3	2.0	0.43	.00035	.0329
Loose coarse gravel.....	0.9	0.6	1.35	.00991	.0337
Gravel; "horse tail moss" over $\frac{3}{4}$ of perimeter	24.6	29.1	0.84	.00033	.0352
Coarse rock.....	0.8	0.8	1.02	.0121	.0365

GROUP No. 7

 $n=0.0377$ to 0.0424

Channels rough and rocky.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Rough; coarse gravel and cobbles.....	1.5	1.1	1.33	.0171	.0377
Rocky; overgrown with alfalfa.....	2.5	5.6	0.44	.0029	.0393
Rough; coarse gravel.....	1.2	1.1	1.10	.0170	.0423
Loose gravel; long waving water plants.....	31.1	20.4	1.52	.0012	.0424

GROUP No. 8

 $n=0.0469$ to 0.0529

The characteristic of this group was the heavy vegetation in the channels.

Character of Channel	Dis-charge	Area Water Section	Mean Vel.	Slope	n
Natural stream; $\frac{1}{3}$ full of "horse tail moss".....	0.3	0.5	0.54	.0044	.0469
Canal; more than half full of "horse tail moss"; edges overgrown with weeds; bottom fine gravel.....	23.4	35.8	0.65	.00028	.0499
Lateral; $\frac{2}{3}$ full "horse tail moss".....	1.1	2.6	0.42	.00107	.0519
Ditto.....	1.1	2.9	0.37	.00064	.0529

In 1908 some observations were made on irrigation ditches in the northern part of Colorado with a view of obtaining further data on the value of n . This was chiefly done by Mr. Arthur C. Preston as thesis work in the Department of Civil Engineering. The readings were taken with a Price current meter generally, the six-tenths method being used, that is, the velocity at 0.6 the depth was taken as the mean velocity for each division of the cross-section. The results of these observations will now be summarized. The photographs were mainly taken at other times than when the readings were made, usually when the water was very low or else was not flowing at all, in order to show the character of the channel to better advantage. The results are tabulated at the end.

Observation No. 1. EMPIRE INTAKE CANAL

This canal is the largest and in the best condition of those tested. The alignment throughout the 400 feet is perfectly straight, the banks

retain their original slopes of 2 : 1 and the grade is uniform. The channel is composed of firm gravel and sand of which no pebbles are over one half-inch in diameter, and is clean and free from vegetation. It has been in use two years as a carrier of water for storage. See Figs. 1, 1a and 1b.

Observation No. 1b

This experiment was performed on the above canal at the same section to ascertain the influence of varying discharge. A series of tests for this purpose was planned but was interrupted by adverse conditions.

Observation No. 2. LOUDEN DITCH

The Louden ditch at this point is a wide, shallow canal with a clean, sandy bottom entirely free from weeds or aquatic growth. The banks while rough at the top are worn to the usual elliptical shape in the portion of the cross-section regularly filled with water; the ditch on the whole would be considered as being in fair condition. See Figs. 2 and 2a.

Observation No. 3. RIST AND GOSS DITCH

This ditch was the smallest on which readings were taken and was also one of the best as regards general condition. Although a main canal, it is scarcely larger than a lateral, averaging only five or six feet in top width. It is built in heavy loam and the sides and bottom are coated with sediment. There are no weeds which interfere with the flow and there is no aquatic growth.

Observation No. 4. OLD BARNES DITCH AT LAKE LOVELAND INLET

The ditch at this point is in very good condition. It is constructed in firm earth and the channel is well coated with sediment. There are no stones or pebbles of consequence. The banks are smooth and regular. Long grass overhangs the sides, but it does not hinder the flow of the water. There is no aquatic growth. See Figs. 4 and 4a.

Observation No. 5. GEO. RIST DITCH

The readings on this ditch were taken about one half-mile below the headgate. The ditch is built in coarse mesa material varying from

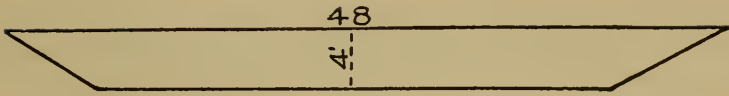


Fig.1a. Empire Intake Canal

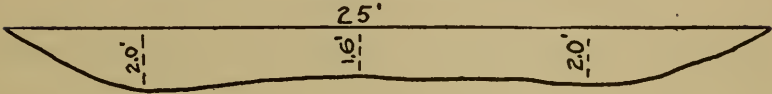


Fig. 2a. Louden Ditch

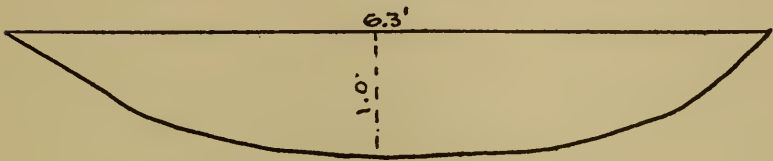


Fig.3a Rist & Goss Ditch

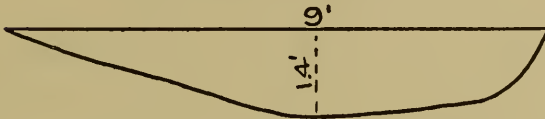


Fig.4a. Old Barnes Ditch

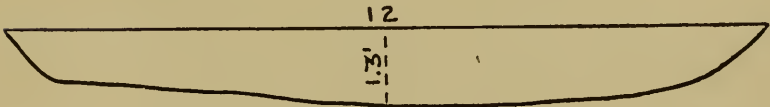


Fig.5a. Geo. Rist Ditch

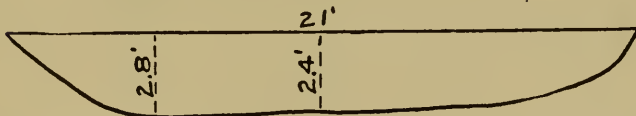


Fig.6a. Home Supply Ditch

earth to coarse gravel, with occasional cobblestones up to six inches in diameter. Fig. 5 shows the unevenness of the banks and how they are overhung with sod. The channel is well lined with sediment. The cross-section is shown in Fig. 5a.

Observation No. 6. HOME SUPPLY CANAL

The banks of this canal are in poor condition owing to the overhanging rough sod. The bottom is composed of clean, firm sand and fine gravel. The alignment in the portion tested is straight and the cross-section is very uniform. See Figs. 6 and 6a.

Observation No. 7. LOVELAND AND GREELEY CANAL

The banks of this canal have sod and grass overhanging and projecting into the water. The channel is composed of earth with many cobblestones up to eight inches in diameter lying in the bottom. The portion of the canal tested is on a curve. See Figs. 7 and 7a.

Observation No. 8. HANDY DITCH

The Handy ditch is in very poor condition, the gradient lacking uniformity and the banks being very ragged. The portion tested is on a curve, the outer bank of which is protected by riprap. The channel is composed of coarse gravel and pebbles. See Figs. 8 and 8a.

Observation No. 9. HILLSBORO DITCH

This canal has a very irregular gradient and its general condition is bad. The banks are rough and the channel, which is of gravel, is badly scoured by the current. The test was made just above the rating flume and where the alignment is not perfectly straight. The water was within half a foot of the top of the left bank when the readings were taken. See Figs. 9 and 9a.

Observation No. 10. THOMPSON MFG. CO. CANAL

This canal has ragged overhanging banks with trailing weeds and grasses. The cross-section is irregular and the grade is excessive. The channel contains cobblestones six inches in diameter. The water

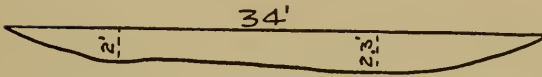


Fig.7a. Loveland & Greeley Canal

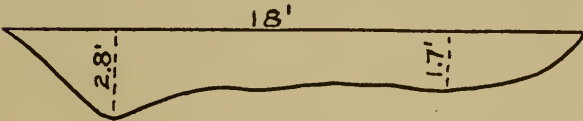


Fig.8a. Handy Ditch

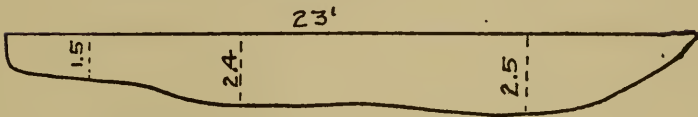


Fig.9a. Hillsboro Ditch

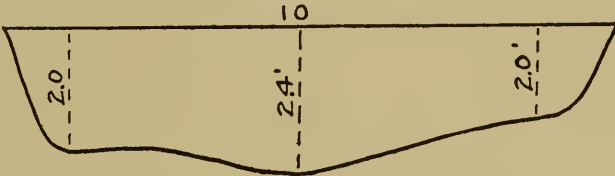


Fig.10a. Thompson Mfg. Co. Canal

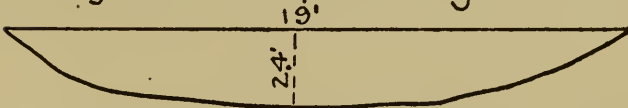


Fig.11a. Farmers' Ditch

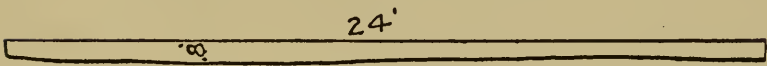


Fig.12a. Beasley Ditch

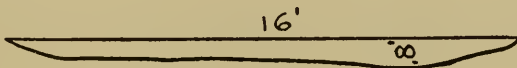


Fig.13a. Beasley Ditch

section within one foot of the top is choked with a dense growth of an aquatic plant, milfoil. The unfavorable conditions affect the flow to such an extent that while the mean velocity is only 1.58 feet per second, the surface velocity is 3.7 feet per second. See Figs. 10 and 10a.

Observation No. 11. FARMERS' DITCH IN LOVELAND

This ditch is in fair condition as to cross-section, alignment and material, but it is about half filled with milfoil. The gradient is enough to produce a high velocity, but the aquatic growth keeps the mean velocity low. See Figs. 11 and 11a.

Observation No. 12. BEASLEY DITCH AT BOULDER

The channel here is wide and shallow. It is through gravel and fine sand with a good many small cobblestones on the bottom. The banks are held in place by logs laid parallel to the stream. Fig. 12 shows the bed where there was but very little water in it. Fig. 12a is a cross-section of the channel.

Observation No. 13. BEASLEY DITCH NEAR WATER ST.

The bed of the ditch at this point is composed of gravel on the bottom with cobblestones at the sides. The channel is unobstructed by vegetation. The alignment is on a slight curve. The general condition of the ditch at this point would be classed as good. See Figs. 13 and 13a.

Observation No. 14. INTERSTATE CANAL¹

This canal is designed to carry 1,421 second feet at a velocity of 2.9 feet per second and with a depth of ten feet. The friction factor used is 0.025. However, owing to the high velocity attained which endangered the channel, the maximum flow allowed is 830 second feet. The corresponding friction factor is 0.012.

The following conclusions seem evident from the data at hand:

1. These experiments as well as those of Professor Fortier seem to show that $n=0.025$ is too high a value for design, especially for large canals. This is exemplified in Observation No. 14.

¹ Reported by H. E. Sovereign.

2. It is difficult if not impossible to assign values to n for canals in which there is much aquatic growth. In the Thompson Mfg. Co. canal, for example, the mean velocity was 1.58 per second, while the surface velocity was 3.7 feet per second. This discrepancy was due to the choking of the channel by milfoil.

3. Rough and uneven banks have as much influence on the flow as an uneven bottom.

4. It seems that cross-currents and internal friction exercise a considerable influence on the velocity. These are not directly provided for in Kutter's formula. It appears, therefore, that if the flow is without cross-currents and internal friction, there is not much variation in the value of n whether the channel through which the water flows is of earth, gravel or some smooth material such as cement. For this reason cobblestones and other projections exercise considerable influence in small canals but cut very little figure in the larger ones.

TABULATION OF RESULTS

Obs. No.	Area Sq. Ft.	Wetted Perimeter Ft.	Hydraulic Radius	Slope	Dis-charge Sec. Ft.	Velocity Ft./Sec.	C	n
1.....	71.2	41.3	1.73	.00050	175.5	2.46	83.6	.0194
1b.....	135.9	47.7	2.84	.00025	372.1	2.94	103.0	.0170.
2.....	37.3	24.5	1.52	.00038	62.0	1.66	69.0	.0220
3.....	3.6	6.3	0.57	.00034	3.3	0.91	65.0	.0204
4.....	8.5	9.0	0.95	.00032	9.9	1.17	67.0	.0206
5.....	11.0	12.1	0.91	.00040	12.7	1.15	60.2	.0224
6.....	46.0	23.4	1.96	.00040	88.0	1.91	68.2	.0238
7.....	59.2	35.0	1.69	.00050	100.0	1.69	58.2	.0267
8.....	31.0	18.9	1.64	.00090	51.0	1.64	42.6	.0356
9.....	50.1	26.7	1.87	.00060	72.0	1.44	42.8	.0371
10.....	16.5	12.5	1.32	.0032	26.0	1.58	24.4	.054
11.....	33.4	19.9	1.68	.00090	30.0	0.90	23.1	.063
12.....	12.1	25.0	0.48	.0014	13.3	1.10	42.5	.0320
13.....	7.4	16.6	0.44	.00093	12.9	1.74	87.0	.022
14.....	207.5	52.1	3.88	.00017	830.	4.75	185.0	.012



FIG. 1.—EMPIRE INTAKE CANAL



FIG. 1b.—EMPIRE INTAKE CANAL; RATING STATION



FIG. 2.—LOUDEN DITCH



FIG. 3.—RIST & GOSS DITCH



FIG. 4.—OLD BARNES DITCH



FIG. 5.—GEO. RIST DITCH



FIG. 6.—HOME SUPPLY DITCH



FIG. 7.—LOVELAND & GREELEY CANAL



FIG. 8.—HANDY DITCH

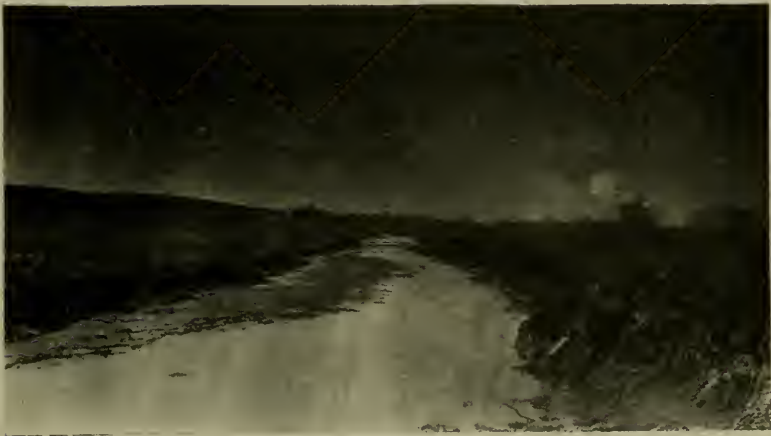


FIG. 9.—HILLSBORO DITCH



FIG. 10.—THOMPSON MFG. CO. CANAL



FIG. 11.—FARMERS' DITCH

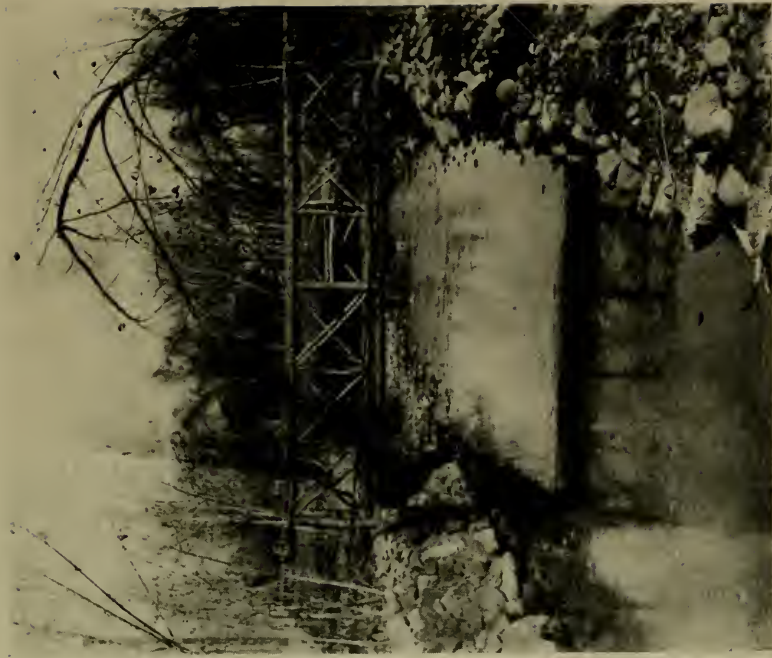


FIG. 13.—BEASLEY DITCH



FIG. 12.—BEASLEY DITCH

ALPHABETICAL INDEX OF VOL. VII

	PAGE
Ants of Northern Colorado	215
Ayer, Charles C.	63
Bees, Study of Rocky Mountain	179
Birthrate, Declining	159
Borrowings and Adaptations from the <i>Iliad</i> and <i>Odyssey</i> in Matthew Arnold's <i>Sohrab and Rustum</i>	73
Boulder Park [Plant Communities]	223
Cockerell, T. D. A.	130, 149, 179
Colorado:	
Amphibians	130
Ants	215
Bees	179
Birds	132
Botany	115, 223
Climatology	112
Fossil Invertebrates	146
Fossil Plants	149
Freight Rates in	5
Geology	101
Insects	126, 215
Mammals	132
Mountain Laboratory	91
Mollusca	125
Paleontology	146, 149
Reptiles	130
Scientific Expedition	101
Color Perception	207
Declining Birthrate	159
Derham, Milo G.	73
Felger, A. H.	132
Foreign Drama on the English and American Stage	63
Freight Rates and Manufactures in Colorado	5
German Drama	63
Henderson, Junius	101, 125, 146
Henmon, V. A. C.	207

Introduction to the Study of the Ants of Northern Colorado	215
Introduction to the Study of Rocky Mountain Bees	179
Irrigation Ditches	237
Libby, Melancthon F.	201
Northern Colorado Plant Communities	223
Notes on the Flow of Water in Irrigation Ditches	237
Phillips, John Burton	5, 159
Plant Communities [of Boulder Park]	223
Pre-Thalesian Philosophy	201
Ramaley, Francis	91, 223
Robbins, W. W.	112, 115, 179, 215
Rocky Mountain Bees	179
Sex Differences and Variability in Color Perception	207
Scientific Expedition to Northwestern Colorado in 1909	101
Study of Rocky Mountain Bees	179
Tolland, Colo. [Mountain Laboratory at]	91
University of Colorado Mountain Laboratory	91
Williams, Clement C.	237

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