Fifth biennial report of the Kansas State Board of Agriculture

Section 27, Pages 781 - 810

This biennial report covers the years 1885-86. The volume contains two parts and the page numbering starts over at the beginning of part II. The volume contains numerous agricultural statistics and information about other industries. It also contains information about Kansas weather, schools, churches, various agricultural issues such as Texas fever, chinch bugs, vacant public lands, etc. A major part of the volume is devoted to information gathered during the 1885 statewide census conducted by the Board of Agriculture. Part I contains a number of tables with statistics about Kansas residents broken down by county. Part I also contains a section on each county, providing summary information about the history of the county, nativity of residents, a description of the landscape, crops, livestock, schools, newspapers, banks, and a list of county officers for 1887. Proceedings and other activities of the Kansas State Board of Agriculture are in Part II.

Creator: Kansas. State Board of Agriculture

Date: 1887

27 days, there was an entire absence of rain. From the same date to September 16th, a period of 81 days, the rainfall was but 2.85 inches. In 1874 the drouth extended from June 14th to September 3d, an interval of 80 days, during which the rainfall was only 2.19 inches. Thus the drouth of 1886 was one day longer than that of 1874, but the latter began nearly two weeks earlier in the season, and was therefore more disastrous in its effects.

SNOW.

The entire depth of snow was 23.50 inches, which is 1.96 inches above the average. Of this amount 12 inches fell in January, 1 inch in February, 4 inches in March, 4 inches in April, half an inch in November, and two inches in December. Snow fell on 31 days. The last snow of spring was on March 27th. The first snow of autumn was on November 11th—3 days later than the average date.

FACE OF THE SKY.

The mean cloudiness of the year was 39.64 per cent., which is 4.99 per cent. below the average. The number of clear days (less than one-third cloudy) was 189; half clear (from one to two-thirds cloudy), 91; cloudy (more than two-thirds), 85. There were 59 days on which the cloudiness reached or exceeded 80 per cent. There were 64 entirely clear and 39 entirely cloudy days. The clearest month was October, with a mean of 25.91 per cent.; the cloudiest month was January, mean 61.93 per cent. The percentage of cloudiness at 7 A.M. was 44.03; at 2 P.M., 44.46; at 9 P.M. 30.44.

DIRECTION OF THE WIND.

During the year, three observations daily, the wind was from the N. W. 227 times, S. W. 221 times, S. E. 172 times, N. E. 157 times, S. 137 times, N. 77 times, E. 65 times, W. 39 times. The south winds (including southwest, south, and southeast) outnumbered the north (including the northwest, north, and northeast) in the ratio of 530 to 461.

VELOCITY OF THE WIND.

The number of miles traveled by the wind during the year was 127,769, which is 9,070 miles below the annual average for the preceding 13 years. This gives a mean daily velocity of 350.03 miles, and a mean hourly velocity of 14.58 miles. The highest velocity was 70 miles an hour, on March 21st; the highest daily velocity—the second highest on our record—was 1,120 miles, on the 8th of January; the highest monthly velocity was 13,900 miles in March. The windiest months were January, March, April and November; the calmest months were May, June, July and August. The average velocity at 7 A. M., was 12.56 miles; at 2 P. M., 16.06 miles; at 9 P. M., 13.77 miles.

BAROMETER.

Mean height of barometer column 29.111 inches, which is .004 inch above the annual average. Mean at 7 A. M., 29.128 inches; at 2 P. M., 29.092 inches; at 9 P. M., 29.114 inches; maximum, 29.788 inches, on December 4th; minimum, 28.482 inches, on February 9th; yearly range, 1.306 inches. The highest monthly mean was 29.254 inches, in December; the lowest was 29.037 inches, in July. The barometer observations are corrected for temperature and instrumental error only.

RELATIVE HUMIDITY.

The average atmospheric humidity for the year was 66.5; at 7 A. M., 76.9; at 2 P. M., 50.0; at 9 P. M., 72.5. The dampest month was January, with mean humidity, 83.0; the driest month was July, mean humidity, 58.4. There were only 5 fogs during the year. The lowest humidity for any single observation was 16 per cent., on November 2d and 22d.

The following tables give the mean temperature, the extremes of temperature, the

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number of inches of rain and snow, the number of rainy days, the number of thunder showers, the mean cloudiness, the relative humidity, the number of fogs, the velocity of the wind, the mean and extreme barometer heights for each month of the year 1886, and a comparison with each of the 18 preceding years.

YEAR 1886.

1886.	Mean temperature	Maximum temperature	Minimum temperature	Rain, inches	Snow, inches	Rainy days	Thunderst'rms	Mean cloudiness	Humidity	No. of fogs	Miles of wind	Mean barometer	Maximum barometer	Minimum barometer
January	14.32	41.5	-18.0	2.28	12.0	15	0	61.93	83.0	2	13,090	29.200	29.721	28.627
February	31.64	62.0	-7.0	0.56	1.0	7	1	42.38	73.6	2	11,170	29.166	29.725	28.482
March	40.40	79.0	11.0	1.63	4.0	10	1	55.05	67.7	0	13,900	29.069	29.510	28.589
April	54.80	85.0	19.0	1.38	4.0	12	2	52.66	65.1	1	13,040	29.053	29.427	28.640
May	68.50	91.0	44.0	5.72	0.0	9	6	34.52	67.9	0	7,920	29.024	29.322	28.620
June	71.85	92.0	49.0	3.71	0.0	12	3	38.00	68.4	0	6,372	29.052	29.437	28.804
July	79.54	100.0	57.0	0.11	0.0	4	2	31.83	58.4	0	6,857	29.037	29.183	28.853
August	79.02	105.0	51.5	2.49	0.0	11	6	28.60	60.1	0	8,840	29.048	29.214	28.861
September	71.19	97.0	42.0	2.34	0.0	8	3	32.00	60.7	0	10,315	29.090	29.377	28.731
October	60.23	86.0	27.0	1.59	0.0	4	3	25.91	59.1	0	10,865	29.219	29.416	28.795
November	40.08	76.0	15.0	1.61	0.5	5	1	35.11	63.6	0	13,230	29.121	29.551	28.523
December	24.03	58.0	-6.0	0.83	2.0	6	0	37.77	73.4	0	12,170	29.254	29.788	28.825
Means	52.96	81.0	23.7	2.02	2.0	9	3	39.64	66.5	.04	10,647	29.111	29.473	28.696

NINETEEN YEARS: 1868–1886.

Year	Mean temperature	Max. temperature	Min. temperature	Hot days (ab've 90°)	Zero days	Days between severe frosts	Rain, inches	Snow, inches	Rainy days	Thunder storms	Mean cloudiness	Humidity	No. of fogs	Miles of wind	Mean barometer
1868	52.77	101.0	—10.5	43	7	160	37.48	27.50	77	......	42.35	....	......	....	....
1869	50.51	96.0	— 5.0	23	2	167	38.51	18.00	105	33	49.23	78.2	19	....	29.103
1870	53.70	102.0	—10.0	51	6	197	31.32	9.50	100	27	47.88	68.4	13	....	29.097
1871	53.56	103.0	— 6.0	48	8	218	33.23	29.75	120	24	47.37	65.9	6	....	29.076
1872	51.30	97.0	—18.0	45	16	192	32.63	23.25	116	40	44.33	64.4	11	....	29.112
1873	51.96	104.0	—26.0	48	9	165	32.94	26.50	101	17	42.46	64.0	6	154,508	29.093
1874	53.68	108.0	— 3.0	58	2	187	28.87	43.00	99	20	45.54	65.7	14	145,865	26.121
1875	50.60	99.0	—16.5	32	12	196	28.87	5.00	106	21	44.81	66.7	5	145,316	29.102
1876	52.76	98.0	— 5.0	36	4	179	44.18	25.75	102	29	41.27	66.8	4	148,120	29.102
1877	54.16	99.0	— 9.0	20	3	217	41.09	15.50	126	39	47.12	72.6	11	113,967	19.117
1878	55.33	98.0	— 6.0	35	7	228	38.39	25.50	107	38	40.65	70.2	5	125,793	29.067
1879	54.67	99.5	—16.0	48	13	203	32.68	10.35	90	36	40.01	67.1	10	124,768	29.127
1880	54.01	101.0	—12.0	41	2	211	32.65	7.00	89	29	40.15	67.9	18	146,039	29.123
1881	54.65	104.0	— 8.0	68	6	210	33.27	32.50	110	31	47.42	70.1	11	141,430	29.103
1882	54.94	105.0	— 6.5	40	1	232	27.60	18.00	102	26	45.41	68.6	14	137,736	29.113
1883	51.66	96.5	—14.0	26	8	217	40.65	12.50	106	32	45.24	69.7	18	141,164	29.135
1884	51.30	98.0	—21.5	20	14	198	43.70	29.00	105	35	47.56	72.6	28	131,188	29.111
1885	51.01	96.0	—14.5	27	21	176	36.97	33.00	103	31	44.57	71.3	9	123,013	29.107
1886	52.96	105.0	—18.0	53	16	203	24.25	23.50	103	28	39.64	66.5	5	127,769	29.111
Mean.	52.92	105.0	—12.2	40	8	198	34.70	21.85	104	30	44.37	68.7	12	136,191	29.107

STUDIES ON RAINFALL IN KANSAS AS AFFECTING CLIMATE.

By its position and motions in the solar system, the earth is possessed of diversified climates. We have the regions of perpetual frosts around the poles, because they are turned away from the light and heat-giving influences of the sun, and on the other hand, where his direct beams strike the equatorial zone, dwells perpetual summer. Between these extremes, the gradation from one to the other gives us every variety with respect to heat.

Another important factor in climate is moisture. Here we find the distribution of the seas and the configuration of the continents have much to do with the existing state of things. The great atmospheric ocean, on whose bottom we dwell, is the vehicle by which the solar rays lift the oceans on high, and scatter them abroad in fertilizing showers, so that at last they may appear as cooling springs, rippling brooks, and mighty rivers, and return once more to the ocean basin to repeat this beneficent cycle. The distribution of atmospheric precipitation cannot be marked out by parallels nor meridians. We find arid deserts in the torrid belt, and plains almost as dry in Siberia. There are regions where snow is perpetually falling, as well as tropical countries of constant rain.

As has been said, the distribution of the oceans and arrangement of continents must be taken into account. If the prevailing wind tends to cross a mountain range, it will either be deflected by or have its moisture wrung out in passing over the summit.

It thus appears, at first view, that climate is determined by the great forces and order of nature which man is powerless to alter. We may inquire whether climates have changed, or are changing, under any agencies. To this it must be answered, that great changes have undoubtedly occurred, and are going on now.

To say nothing of the revolutions which geology records so plainly, when arctic regions were sub-tropical, or again, when the rivers of ice plowed as far south as Kansas, there have been changes of considerable magnitude within recent historic times. Some of the Windward isles, clothed not long ago in tropic verdure, and densely populated, are now barren and abandoned, having literally been dried up by some unexplained change in the wind currents which brought the rain. Palestine and Syria do not now appear to merit the description of lands flowing with milk and honey; and bad government and lack of proper husbandry hardly account for such a change as has come to pass in these lands. Greenland and Labrador have undoubtedly a more rigorous climate than when the Norsemen were attracted to and made settlements on their shores. These are a few cases of many that might be given, where climates have changed according to human records.

The changes of climate of most interest to us, are connected with rainfall very intimately. It is a question of great importance, How does civilization affect a climate? and we in America have better opportunity than others to answer this question. Our history is not so long that we cannot ascertain pretty accurately what changes, if any, have occurred since the Europeans landed on these shores. A generation has scarcely passed since a large part of our Western plains were in the savage wildness of nature.

Now, in order to ascertain the truth in inquiries of this kind, we must resort to exact records. It will not do to trust to the memory of the oldest inhabitant, which would leave us scarce a season without a phenomenally cold or hot day, or an unprecedented storm. Neither can we rely upon the Sybil-like utterances of the old Indian, sharp though he be as an observer. Still less would I take stock in the whole catalogue of weather prophets, who mix a little worn-out astrology with half-truths of science, and by chance and human credulity gain a brief notoriety. It is not my purpose at all at this time to attempt the laborious inquiry involved in considering our whole country, trying to ascertain the changes of climate since its settlement, but rather to bring a little contribution to the consideration of the climate of our own State, by presenting a few studies on the rainfall in Kansas. I will premise by calling attention to the general impression that there has been a marked change here in rainfall since Kansas became a State. Many are impatient of argument on this point — they just *know* that rain is now more abundant than a quarter of a century or even ten years ago, and no more need be said of it. They point to the treasures of the golden belt, and refer with cutting irony to those explorers and writers who in early times included Kansas in the Great American Desert. Now I do not propose to take sides in this question, but try to present fairly the facts that are in my possession.

In reports made to this honorable Board by Prof. Snow, and other meteorologists, this question of rainfall has received considerable attention. All who have studied the problem agree that our data are as yet inadequate to a complete answer, since the records are all so recent.

We have, fortunately, at the military post at Fort Leavenworth, a record that goes back half a century, whose only serious break occurred in 1865 and 1866, during the war of the Rebellion. The next oldest weather record is that of Fort Riley, which, with the supplement of the Manhattan record at the Agricultural College, carries us back to 1854. From Fort Scott, we have quite a complete report from 1843 to 1853; from Fort Hays, from 1867 to 1874; from Fort Harker, from 1866 to 1872; from Fort Larned, from 1861 to 1874.

The reports from Lawrence date from 1861, but the record is not complete till 1869, when Prof. Snow began his admirable work, which for the last twenty years leaves nothing to be desired from that station. The volume of the transactions of this Board published in 1874 gives the reports above referred to up to that date, they having been furnished through the courtesy of Prof. Henry, then Regent of the Smithsonian Institution.

Since then each biennial report of the Board of Agriculture has added to these records, and new observers have been at work all over the State making contributions, which will form a basis for future studies.

I have endeavored to present graphically a compilation from the Leavenworth, Manhattan and Lawrence records, from which we may draw conclusions as to variations in rainfall.

The curves are constructed as follows: Years are designated by equal spaces on the horizontal lines. The perpendiculars show by their length the amount of rainfall in inches. The curve drawn through the summits of these exhibit the variation from year to year, and also a comparison of the three points, Leavenworth, Lawrence, and Manhattan.

Now this is at best a partial view. It does not show what variation has occurred in the western half of the State, nor in the southern. We may however conclude that no great change in the total amount of rain is probable. This is what we might expect when the sources of rain are considered. It is also true that this presentation has left out of account the distribution of the rains through the seasons and months. Fortunately for Kansas, our driest months are in winter, when moisture is not so much needed, and the depth and richness of our soil gives an immunity to crops in dry periods that would be fatal in less-favored localities.

We notice from the chart that extremes follow each other in regular sequence. We have had no more than two or three dry or wet years in succession. We find, as we should anticipate, a greater rainfall at Leavenworth than at Lawrence, and still less at Manhattan. This does not prevent the Manhattan curve from rising occasionally above the others, as in 1876, and in 1882 and 1886 Leavenworth was lowest of the three.

The curves in general are a little steeper on the left-hand side, which shows the change from dry to wet seasons to be more abrupt than from wet to dry. The chart gives at a glance an array of facts that require otherwise columns of figures to present, and to most people the graphic method is the more interesting. We also give the figures which form the basis of the compilation of the chart, with a few other tables from which other curves of less extent might be drawn.

Another very interesting consideration is the *effect* of rains now, as compared with former times. Here we may be pretty confident that cultivation is of great service in utilizing the rains. The soil that is worked and pulverized absorbs moisture from the air, even when there is no precipitation, and the rains sink into it and are retained better than in hard, compact soil. Then, again, the wild grasses seem to send their roots deeper and depend less upon the surface moisture than do the plants that follow cultivation. They are adapted to their environment, and help to turn the rain from the general surface into the water-courses. Thus it has been observed that brooks and streams discharge less water as cultivation advances in the western part of the State. This means that the total discharge is less, and of course is only a rough estimate, since it would be difficult to measure the annual discharge of streams with any certainty. It is also observed that stream-beds in many parts of the State, which formerly were dry except in times of rain, have now living springs breaking out along their course, which seems to indicate that more water has soaked into the soil, and is slowly working its way to the stream-bed instead of rapidly running off over the surface. In this respect, the cultivation of our prairies has had an opposite effect from that which has followed the clearing away of forests on the hills of New England, which the settlers found covered with a dense growth of timber. The ground was overspread with humus from the decaying wood and leaves, which retained the rains and made their discharge into streams slow and uniform. It was the aim of the early settlers to clear away the forests as rapidly as possible, and their successors may well mourn their triumph in this direction. The hills were stripped of timber, the fire burned up the leaves and rich vegetable mould which kept the ground moist; and then there was nothing to check the floods from melting snows and rains, which have borne away to the ocean no small fraction of New England's agricultural resources. The streams there have dried up, and likewise the springs, and this state of things will grow worse rather than better, unless the hills can be replanted and become once more reservoirs for water supply.

The effect of tree-planting in our own State should be noted. The national and State laws have fostered this branch of agriculture, and every year tens of thousands of trees and thousands of miles of hedge-rows are planted in Kansas. Nothing has contributed more to change the prairie landscape and relieve it from the aspect of barrenness. Every tree and shrub contributes to the humus of the soil, and thus helps to retain moisture. They shelter the ground from the scorching rays of the sun, and lift through their roots no small amount of water to be distributed into the air through their leaves. In times of drouth trees monopolize the water supply and prevent the growth of smaller plants near them. With the advent of trees must be seen the disappearance of the prairie fires, which have no doubt much to do with these plains being treeless, as the settlers found them. Indirectly, the trees will help to retain moisture by keeping off the fires, but if the trees have any direct agency in causing rains, it is not determined. Opinions differ on this point, but all agree that trees favor humidity; but humidity of air and rainfall are quite different phenomena.

From these considerations we may fairly claim that Kansas climate is becoming more and more favorable for agriculture, and this without the need of proving that the rainfall has greatly changed. Our methods for ascertaining humidity are so far from being easy and accurate that we must wait yet some time before we can claim, on basis of accurate observation, that our climate is becoming more humid.

We may expect in the future, as in the past, wet seasons and dry seasons. We find often that these alternate year by year, and if the change is not annual we have two, three or four years of excessive rains followed by an equal period when the rainfall is below the average. Going from the eastern to the western border of Kansas, we shall undoubtedly find a regular diminution of rainfall, though the last season seemed an exception. It would be hazardous for anyone to base his calculations on this exception becoming a rule. Kansas farmers are learning, sometimes by bitter experience, how to make the most of their surroundings. There is no part of the State so dry that some kind of husbandry will not succeed in it, and it is the part of wisdom to find out as soon as possible where the path to success lies.

ANNUAL RAINFALL, IN INCHES.

Year.	Ft. Leav'n-worth.	Manh'ttan	Lawrence.	Ft. Scott.	Fort Larned.	Topeka (Washb'rn College.)	Dodge City.	Welling-ton.	Wallace.
1836	*[30.66]								
1837	38.45								
1838	26.28								
1839	33.32								
1840	32.14								
1841	[25.90]								
1842	[26.29]								
1843	15.94			44.53					
1844	48.12			62.60					
1845	34.56			61.59					
1846	23.75			34.04					
1847	21.03			34.36					
1848	37.99			29.25					
1849	42.85			45.43					
1850	27.07			30.03					
1851	37.81			33.01					
1852	36.53			46.52					
1853	25.20								
1854	24.40	16.93							
1855	27.55	26.25							
1856	42.72	24.84							
1857	31.71	17.98							
1858	59.65	31.97							
1859	38.84	36.17							
1860	19.38	14.72							
1861	27.27	35.35							
1862	29.50	27.80							
1863	[30.40]	40.54							
1864	[15.93]	20.08							
1865	[50.88]	34.23			36.50				
1866		23.73							
1867	[25.72]	26.50			18.35				
1868	33.18	30.08	37.48		24.70				
1869	35.31	28.22	38.51		14.11				
1870	43.18	21.19	31.32						
1871	56.75	28.62	33.23		13.64				
1872	51.61	35.78	32.63		12.97				
1873	32.16	26.16	32.94		18.23				
1874	33.81	17.61	28.87		21.73				
1875	31.26	17.96	28.87		17.80		10.69		15.85
1876	44.48	46.43	44.18		18.19		15.40		16.98
1877	52.05	43.79	41.09		30.18		27.89		16.61
1878	35.15	39.10	38.39				17.96		19.28
1879	41.55	36.86	32.68			33.14	15.43	28.96	16.56
1880	36.86	29.11	32.65			32.77	18.12	19.70	34.10
1881	39.95	28.94	35.27			26.33	33.55	39.47	8.38
1882	25.97	28.35	27.60			25.22	13.14	36.10	
1883	41.04	36.79	46.65			44.43	28.50	40.49	
1884	44.72	33.62	43.70			42.62	30.36		
1885	43.70	25.09	36.97			30.35	27.76		
1886	22.45	27.25	24.25			23.23	15.14		

* Figures inclosed in brackets were obtained by interpolation.

WHAT CONSTITUTES A GOOD SOIL.

BY E. H. S. BAILEY.

In the early history of the country, the question of fertility of soil was not asked as frequently as now. The settlers cleared the forest and built their cabins, and considered themselves fortunate if they had a large-enough clearing to raise corn, rye and potatoes enough for home consumption.

To-day the case is altogether a different one. Eastern farmers have long since learned that the resources of the soil are not exhaustless, and they have either given back to Nature some of the plant-nourishing material of which they have robbed her, or have abandoned the old farm and "gone West." In our own rich and mellow soil there seem to be boundless possibilities, and the golden grain yields a golden harvest to the prosperous farmer year after year. Nature is to be thanked for her generosity, for the store of fertilizing material in the soil, and for the fact that it is in a form so readily available for plant growth.

Upon how many and what varied conditions does the fertility of the soil depend! If *any* of these are wanting, the soil is deficient and cannot sustain the growing plant to perfection.

First, the fineness or coarseness of the soil has a great effect. The composition may be never so good, yet if the soil is coarse and rocky, the constituents are not readily washed out by the rains so as to be available. Again, it may be of such composition as to retain all the water and be too wet, or it allows all to drain off, and becomes too dry. The quality of the subsoil has a great influence on this.

It is often assumed that the fertility of the soil depends alone on its chemical composition. True, a certain amount of potash, lime, silica, phosphoric acid, organic matter, iron, and so forth, are necessary for the growth of the plant; but its growth depends on many other factors. Most important of these is the *availability* of these materials. There may be, for instance, an abundance of potash; but if present in combination with silica and other insoluble materials, it is of no value at present. As the rock becomes disintegrated by the action of frost and moisture, it gradually will become available.

But few analyses of the soil of this State have been made. It is of little importance where the soil is so uniformly fertile. A few years ago it was thought that chemistry furnished the clue to remedying all diseases of soil. Analyze it, see what constituents it lacks, and supply them by fertilizers, and you have a fertile soil. These great supposed possibilities, unfortunately, have not been realized, and to-day we are as far from knowing just what to do for a sick soil as we are from finding a specific for all diseases of the body. We can experiment with the soils and soon find what they need; the analysis *may* be of value, but the practical experiment amounts to a demonstration. Some time since a sample of soil from Garden City was received at the University. Judge L. D. Bailey, who sent the soil, says that it was dug from a cellar four feet below the surface. It is of light color, and like powdered chalk in quality. Corn, millet, etc., grow rank and green from the soil, which has been thrown from cellars and deep wells. This is especially noticeable in such a dry part of the State, and during such a dry season as the past summer. Roots have been found running down beside wells to a great depth, in one case forty-eight feet. At this depth the root was still one-quarter of an inch in diameter. Water was found six feet further down. Another proof of the fertility of the soil is found in the fact that the sand-root, or prairie morning glory, has a bulbous root growing two or three feet below the surface. These roots are never affected by the drouth, and the plant grows luxuriantly. An analysis of this subsoil, made in the University laboratory, shows that it has the following composition, expressed in per cent.:

Insoluble residue, sand, etc.,	71.660
Oxide of iron, (Fe_2O_3,) Oxide of alumina, (Al_2O_3,)	6.550
Lime, (CaO,)	4.410
Magnesia, (MgO,)	1.020
Phosphoric acid, (P_2O_5,)	.178
Chlorine, (Cl,)	.010
Potash, (K_2O,)	.750
Soda, (Na_2O,)	.250
Sulphuric oxide, (SO_3,)	.060
Organic matter,	3.960
Moisture,	9.670
Undetermined, carbonic acid, etc.,	1.482
Total,	100.000

On careful examination of the soil, small, perfectly white lumps may be noticed scattered through it. These prove upon examination to be carbonate of lime, and it is probable that most of the carbonic acid found is present in these lumps, combined with lime. It would seem as though a water saturated with bicarbonate of lime had filtered through this soil, and deposited its solid matter in these little lumps; but why it is not uniformly distributed is difficult to tell.

Considerable work has been recently done on the analysis of soils by Prof. Edgar Richards, of the Department of Agriculture. He makes a distinction between soils and subsoils, the latter being often of a different color and not containing so much organic matter. The subsoils may have been deposited ages ago, while the soil is of more recent formation. It is important to understand that soil is constantly being formed from rocks and minerals and from the decay of vegetable matter. All through the mountainous regions, as in Colorado, it is possible to see the process of soil-making constantly going on. The granite rocks, though considered "firm as the everlasting hills," yield to the gentle touch of rain and frost and the tiny rootlets that force their way into the crevices. The fragments of quartz, feldspar and mica are carried out upon the plains by the resistless force of the mountain streams. If these rocks are soluble, and they all are, to a limited extent, the water dissolves them and becomes itself a nutritive material for plant growth. The atmosphere is also a great storehouse of valuable material. Ammonia and small quantities of nitrates are washed into the soil by the rains, and are soon in a condition to be taken up by the rootlets. The soil is thus receiving constant additions, and in itself, by a chemical process, inert material is brought to a condition in which it can be used.

The subsoil in the analysis above mentioned has no doubt the power to retain a large amount of moisture. This is partly due to the presence of a fair amount of organic matter, and partly to the state of division of the soil. It must have the property not only to retain moisture, but to absorb it from the atmosphere. The sample examined had been exposed to the air of the laboratory for some weeks. This would tend to drive off moisture if it were not strongly retained.

In order to see how this soil compares with others in composition, I quote several analyses. The one marked A is the Garden City subsoil analyzed. B is from Wallace county, Kansas, as analyzed by Prof. G. E. Patrick. C is from a cultivated field in Wyandotte county, as noticed in the report of the Kansas State Board of Agriculture, 1874. D is a soil from Sterling, Kansas, as reported by the Department of Agriculture, Bulletin No. 10, 1886. This produced good crops. E is a Connecticut soil, as reported in the 1882 report of the Connecticut Agricultural Experiment Station. It was a virgin soil, and is an example of one in which there is no lack in *quantity* of nutritious material; but it was not in an *available* condition, as it would bear only very scant crops. G is prairie soil from Dakota; also from Professor Richards's report to the Department of Agriculture.

	A.	*B.*	*C.*	*D.*	*E.*	*G.*
Moisture	9.67	1.896	3.800	.470	2.354	6.275
Silica and insoluble residue	71.66	84.337	82.157	81.832	83.108	69.825
Iron and alumina	6.55	2.060	6.900	6.935	3.575	12.048
Lime	4.41	4.268	.675	2.685	.130	.848
Magnesia	1.02	.422	.063	.690	.130	.868
Phosphoric acid	.178	.173	.080	.017	.038	.112
Sulphuric acid	.06	.041	.386	.044	.059	.120
Potash	.75	.214	.048	.397	.056	.720
Soda	.25	.038	.125	.042	.074	.945
Chlorine	.01	.002	.027	.019	....	.027
Volatile and organic matter	3.96	3.039	5.440	5.150	10.476	8.905
Undetermined and carbonic acid	1.482	3.510	.299	1.719	....	.220
Total	100.000	100.000	100.000	100.000	100.000	100.913

An examination of this table shows:

(1.) A great difference in moisture, which is, no doubt, largely due to different methods of preparation and drying the sample. Less moisture would, of course, mean a greater percentage of other ingredients.

(2.) The more soluble material present, other things being equal, the more material is available for plant growth. The soluble material may be in excess, however, as in the case of a swamp where copperas (sulphate of iron) has collected and poisoned the soil so that plants will not grow.

(3.) Organic and volatile matter, though essential, cannot from its abundance be taken as an index of the fertility of the soil. The barren Connecticut soil (E) contained the largest quantity of these ingredients. Swamp muck and peat frequently contain as much as 18 per cent. of organic matter, yet the soil is not directly available for plant nutriment, though it may be a valuable addition to other soils.

(4.) Lime and magnesia are always present in fertile soils, especially outside of New England, largely in excess of the amount necessary for the growth of crops.

(5.) Phosphoric acid, to be *available*, must be in a soluble form. There are, in some parts of this country and Canada, immense beds of phosphate of lime, which is treated with chemicals to render the phosphate soluble, and sold as a fertilizer. Bones are ground or burned, and treated in a similar way, to render the phosphoric acid available.

(6.) Potash is essential to plant growth, though it is probable that to a certain extent it may be replaced by soda. It comes from the decomposition of feldspathic and similar rocks. It is quite rapidly taken from soils by plants; in fact, the ashes of wood are the chief source of potash for use in the arts.

(7.) Chlorine in combination with sodium, forming common salt, is hardly ever deficient in the soil of this State. In fact, nearly all our waters contain some salt, and in many counties it is only necessary to bore a *deep* well to strike saline water.

In regard to organic matter, it should be noted that the nitrogen contained in it is often an index to the fertility of the soil. Even this nitrogen may be so insoluble as not to be available. Fertilizers have been put upon the market which were very rich in nitrogen, but as these fertilizers consisted mostly of hair and leather scraps, both rich in nitrogen, but at the same time very indestructible substances, the fertilizers were of no value.

In regard to the Garden City subsoil, it would seem by its analysis to possess all the requisites of a good, fertile soil. If at the same time it is in a fine state of subdivision, if it has the property of absorbing enough moisture, and if this material is available, as the luxuriant plant growth upon it seems to indicate, then it cannot be valueless as a factor in the development of the western counties of the State. If the climatic conditions change, as reports carefully kept for the last twenty years would seem to indicate, and thus the area of arable land is extended further west by increased rainfalls, or if irrigation is used, and an artificial supply of water is furnished, then these soils will no doubt produce as abundant crops as those upon the eastern border.

REPORT OF THE STATE VETERINARIAN.

BY A. A. HOLCOMBE, D. V. S.

Since the last report was made from this office, the biennial of 1884, a number of important events, relating to sanitary matters, have transpired. Chief among these were the passage of the Texas-fever law of 1885, the outbreaks of contagious pleuro-pneumonia in Illinois, Ohio, Kentucky, Tennessee and Canada, during 1885 and 1886, and the heavy mortality from hog cholera during 1885.

The demands made upon this office for services have constantly increased, until it has become impossible to answer more than about one-half of them. This condition of affairs should be remedied by the appointment of an assistant whenever necessary. This, however, cannot be done without legislative sanction.

Information regarding the contagious diseases is very generally sought for by many of the stock-raisers of the State, while the sanitary regulations necessary for the protection of the healthy are better understood than ever before. During the two years just ended more than 22,000 copies of reports on the various diseases of the domestic animals have been printed and distributed within the State.

CONTAGIOUS PLEURO-PNEUMONIA.

In the early part of the year 1885, a serious outbreak of this disease was discovered at Fulton, Missouri. It was introduced by a bull from Illinois, which had been exposed to the disease during the summer of 1884. Owing to the very effective measures adopted by the authorities, the outbreak was soon suppressed, notwithstanding the State was without proper sanitary laws. The losses to the State, however, were great, being estimated at $2,000,000.

Outbreaks existed during this period in Kentucky and Tennessee, but early in 1886 they were suppressed by measures adopted by the State authorities. What the losses to Tennessee were is not known, but it is estimated that Kentucky lost at least $12,000,000.

During 1886 a serious outbreak occurred in the quarantine station at Quebec, Canada. All the animals known to be infected have been destroyed, and such quarantine measures adopted as will prevent the further spread of the disease.

In the latter part of the summer of this year the disease was discovered in Illinois, and the investigations made to this date show that it is more extensive than was anticipated. Active measures looking toward its suppression have been adopted by the State, supported by the coöperation of the Bureau of Animal Industry. This outbreak, both by reason of its location and magnitude, promises to be the most disastrous in its consequences of any outbreak that has ever occurred on the continent.

In the Eastern States, which have long been infected, outbreaks frequently occur, and but little has been done in the way of eradicating the plague.

Under the laws passed at the special session of the Legislature of 1884, this State maintains such quarantine regulations against the infected territories as seem necessary to the proper protection of our interests. That these regulations are an absolute protection against the introduction of the disease is not claimed, but they are the best that can be had under the circumstances.

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An outbreak of the disease within our borders would prove a great calamity, and unless provision is made whereby a special fund of about $25,000 is set aside to be used in case the disease makes its appearance in the State, it would be impossible to deal expeditiously with the malady. The Legislature will be asked to make this provision during the session of 1887.

TEXAS FEVER.

The history of this disease in this State is replete with interest to the sanitarian, the legislator, and the public. From the earliest periods in the settlement of the State to the present time repeated outbreaks have occurred, the losses from which in several instances have been immense. In 1869 the Legislature passed the first act by which the damages from this disease might be restricted. Subsequent Legislatures passed other acts, seeking to make the law more effective; but all these measures proved inadequate until the law of 1885 was enacted. The provisions of this law were comprehensive, and after its enforcement for two years it is found to afford ample protection to the whole State.

The total losses to the State during the years of 1885 and 1886 did not exceed $5,000 for each year, while the losses for the year 1884, under the old law, were estimated at more than $500,000. While this law seriously interferes with the commerce in Southern cattle, it is absolutely necessary for the protection of our own interests.

HOG CHOLERA.

The ravages caused by this disease among our swine during 1885 were simply appalling. The most reliable statistics to be had at this time show that the losses in this State during that year exceeded $4,000,000.

But the disease reached its maximum of destruction that year, and the estimate for the losses of 1886 have been placed at $180,000. While this amount is small in comparison with the amount lost in 1885, it is greater than we should be called on to bear, if there are any means by which our swine can be protected. That we shall have as serious outbreaks in the future as we have experienced in the past, is no doubt true, and I am of the opinion that the State should now make provision whereby the disease might be largely prevented and suppressed. This end could be accomplished by placing our swine on the same footing as the rest of our domestic animals, in so far as our sanitary laws are concerned. Section 22 of the sanitary law should be repealed.

GLANDERS.

This is another of the contagious diseases from which the State suffers heavy losses. During the year 1885 fifty-one cases of the disease were discovered, while in 1886 one hundred and seventeen cases were found. Under existing circumstances it is not possible to give this matter the attention which it deserves. To suppress glanders requires a constant supervision of all infected districts for a period of not less than twelve months. The territory infected is so broad that the State Veterinarian alone cannot inspect all the cases reported, much less can he reinspect all exposed animals until the possibility of their being infected is positively determined. The adoption of measures less rigid than those indicated will never rid the State of the disease. To meet the situation fairly, one or two assistants should be appointed, whose duty it should be to inspect certain districts until the last case of the disease is destroyed. At the end of a year's time it would then be possible for the State Veterinarian to give the matter all necessary attention.

TOPEKA, KAS., December 31, 1886.

FISH CULTURE.

BY S. FEE,
STATE FISH COMMISSIONER, WAMEGO, KANSAS.

The subject of fish culture is of such extent that it would not be wise to attempt to treat of it in all its various phases, in a paper of this kind, intended mainly for the benefit of those interested in the question of pisciculture in the State of Kansas.

In discussing the subject, the first question to be settled is, what varieties of fish are the most profitable and best adapted to the wants of the people, as a whole? The artificial propagation of fish is no longer a mooted question, but has become an established fact, which is disputed by none. That being settled, the next question is, what varieties are best adapted to the waters, climate, etc., of the State?

We deem it unnecessary to enumerate the varieties that are *not* suited to our waters, by reason of the absence of the proper conditions for their culture, but will name a few of those that *are* considered suitable, viz.: the Pike family, the Perch family, such of the Catfish family as are desirable and suitable for food, and the Bass family. The above constitute some twelve or fourteen varieties, but only four species or tribes, each species furnishing two or more varieties — enough variety to suit the most fastidious epicure and angler. The foregoing varieties are best suited to propagation in the streams and brooks of the State, and will not thrive to any great extent in the stagnant waters of ponds and lakes.

The object being to furnish the masses — the farmer, mechanics and laborers — in fact every class of our citizens, with an *abundant* and cheap supply of what is considered a wholesome and nutritious article of food, we are led to ask what variety or species of fish will supply this demand and come within the reach of all, so that all may enjoy this luxury — the poor as well as the rich? In answering this query, we are justified, from the experience of those who have given this subject years of careful, patient study and investigation, in saying that the carp family, comprising the Leather Carp, the Mirror Carp, and the Scale Carp, will fill all the requirements needed. The carp being peculiarly a pond fish, thriving only in still or sluggish water, makes its propagation by *almost* every farmer in the State a matter of easy accomplishment.

The question has been, and still is, with a great many, how is the science of pisciculture to benefit me? In reply to such, we would say that there is *no* class of people, from the millionaire to the poorest citizen of the State, but what would be benefited by its development. The farmer who owns a brook or small stream, or has a spot of land full of springs, so that it cannot be cultivated with the plow, can soon, at a *small* outlay of time and money, make each acre of such waste land yield an income that would agreeably surprise him, equaling in its productiveness three or four of the *best* cultivated acres of the farm. To many this may seem impossible, though it is *not* impossible, but an established fact, as has been demonstrated by actual experience.

If you have a small brook fed by living springs, take your teams and plows and throw up two or more low dams, forming a series of ponds, all connected, putting in a wire netting or screen in the overflow of each dam, always guarding the outlet from excessive overflow to prevent the fish from going out. Then plant along the edges pond lilies, the water chinquapin, wild rice, and other kindred plants, so that the water will cover their roots. Then stock your upper pond with bass, or pike, or perch, or carp, as you may desire or can obtain, after which you will have but little trouble or expense. Plant trees at intervals along the banks to afford shade in extreme hot weather, and it will be better for your fish if some deep holes are provided in the ponds to serve as hiding-places. At the end of the second year remove the yearlings from the first pool to the second one, then restock the first; at the end of the third year, allow those in the second pool to enter the third, and pass those from first to second, and restock No. 1 again. Now your brook-ponds are ready to yield an income, with a very small outlay of time or money.

The above directions apply more especially to *small* streams or brooks on the farm fed by springs.

In the case of your low, springy, wet land, where you have not a natural pond or basin, pursue a similar course. Make only one dam, forming a separate pond as large as the limits will allow, or may suit your convenience, and as deep as possible, especially in the middle of the pond. It is not necessary to make the sides perpendicular or steep; in fact they should *not* be. The bottom should slope out gradually, so that water plants of various kinds may grow up and afford food for the carp, and also furnish spawning-ground, as it is in shallow water, among the grass, weeds, etc., that carp deposit their spawn and hatch out their young.

I will here say that the water in *all* portions of the pond should be of sufficient depth to be safe from being frozen to or *near* the bottom in winter, and afford the fish a cool retreat from the extreme heat of summer. The bottom of ponds designed for raising carp should in no case be hard or gravelly, but should be soft, muddy, or mucky. These last observations and directions are designed to be applicable only to carp-raising. As before observed, the carp is peculiarly a *pond* fish, and thrives best and seems to be at home in the pond with a muddy bottom.

It is to the carp family that the farmers of Kansas and the great body of the people must look for a supply of wholesome, cheap food. The carp as a food fish is excelled by but few of what are called the "fine fish;" while many claim that it is equal to *any* of them, when properly handled.

Until very recently it had been thought necessary to place carp, and other fish that hibernate in the muddy bottoms of ponds, in a box placed in clear, running water, to remain two weeks or longer, until the flesh was "purified," and lost the muddy flavor which is said to exist in that class of fish; but that is found by recent experiments to be unnecessary. If the fish is skinned as quickly as taken from the water, there will be found to be *no* disagreeable flavor. The skin, which acts as a strainer, becomes thoroughly charged with mud; but when it is removed, the flesh of the fish will be pure and sweet, and free from any disagreeable or "muddy" taste.

The cooking and serving of fish for the table, to secure the full benefit, is a question but little understood, and should receive the careful attention of the housewife. Of all the modes of cooking fish, none surpasses that of boiling; and for the sick and invalid, this is the only way it should be prepared.

The modes of constructing fish ponds are as various as the locations selected, each location requiring something peculiar to itself, and it is not possible to set out a system which will be suited to *all* the varied requirements, each case being governed by the peculiarities of the location and its surroundings.

Ponds, not *well* supplied with larvæ, worms, bugs, and vegetable matter, in which carp are planted, should be supplied with other kinds of suitable food, which may consist of boiled vegetables, such as potatoes, cabbage, apples, scraps of fresh meat, oats, corn, wheat, etc.—in short, almost anything suitable as feed for pigs or chickens; and like the stock on the farm, the better the feed, the greater the growth of the carp. Hence the pisciculturist should see that his fish are supplied with a sufficient amount of suitable food, otherwise they will be puny and dwarfish, and of no profit to the owner.

I take the liberty of quoting the following questions and answers from the report of the United States Commissioner, on "Inland Fisheries:"

1. Do carp need feeding? A. Yes, to grow fast. They can, however, pick for themselves just as chickens can.

2. What is the best food for carp? A. Cooked cereals and vegetables, such as corn, wheat, rye, potatoes, cabbage, turnips, lettuce, pumpkins, melons, etc.; boiled rice and corn bread are excellent diet for carp. They should be fed morning or evening, or both; do not allow the food to accumulate in the pond and become stale and putrid. Salt mackerel and salt meat should be excluded.

3. Will carp eat tadpoles? A. No.

4. How large do carp grow? A. Sometimes to 50 or 75 pounds.

5. How much will a carp, three years old, weigh? A. If in Pennsylvania, four or five pounds; if in Georgia, six to eight pounds. They grow much faster in a warm climate than in a cold.

6. Will carp destroy their young? A. Not if they can get *any other* food.

7. Do frogs destroy the spawn of fish? A. Yes; they eat both spawn and young fishes.

8. Will minks destroy carp? A. Yes; they will exterminate them.

9. Will mud-cat eat or injure carp? A. They will eat the eggs and young carp.

10. Will mud-turtles eat carp? A. Yes, to extermination.

11. Will roaches feed on carp spawn? A. Yes.

12. Do snakes eat carp? A. Yes.

13. Will suckers injure carp? A. Yes.

14. Will trout destroy carp? A. Yes.

15. How can I guard the carp against frogs, tadpoles, water-rats, and turtles? A. Kill the frogs, tadpoles, water-rats, and turtles.

16. How can I get rid of catfish and tadpoles in the pond? A. Drain the pond.

17. What varieties of fish can carp associate with without detriment? A. There is no kind of fish that will not eat carp eggs and the young carp when they get a chance. Keep carp by themselves.

18. How can I get a supply of young carp for stocking a pond? A. Make application to the State Fish Commissioner, and he will furnish you with proper blanks and instructions for obtaining the carp from the United States Commissioner, who will furnish them, at the annual distribution, which is usually made in Kansas in the month of November of each year.

In this paper we have endeavored to give a general outline of the subject of carp culture, somewhat in detail, for the reason that from this source we must look for the *general* supply of fish for the masses, and the farmers are the class of persons who will ultimately furnish this supply. The subject of pisciculture cannot be treated of in *all* its details in a paper of this kind. And we feel that if we have written anything that will aid or induce any to successfully engage in this enterprise, to their benefit, our labors are not entirely in vain.

WAMEGO, KAS., December 29, 1886.

VEGETATION IN WESTERN KANSAS.

BY CHAPLAIN JOHN D. PARKER, U. S. A., FORT RILEY.

Western Kansas, or that portion of the State lying west of the 98th meridian, comprises an area of about forty thousand square miles. Many people of the Eastern States have the most radical misconceptions of this territory, regarding its soil, climate, and vegetation. Immigrants have been induced to settle on these western plains, without any knowledge of the adaptations of Nature, or any adequate preparation to meet the necessities of the new country, and have lost their possessions. Others, with more knowledge of the country, and with a better preparation to meet its necessities, have made comfortable homes, and are prosperous and becoming wealthy. No problem is presented to the people of Kansas more important than to ascertain the natural resources of western Kansas, to determine the adaptation of soil and climate to vegetation, and to put settlers in possession of facts necessary to make permanent and comfortable homes. Under intelligent treatment, and with proper adaptations to Nature, western Kansas will undoubtedly become one of the richest and most prosperous portions of the West.

Western Kansas consists of high, rolling prairies, interspersed with bottom-lands, and has a gentle slope toward the east and southeast. Passing from the northern to the southern limit of the State, we cross six principal streams — the Republican, Solomon, Saline, Smoky Hill, Arkansas, and Cimarron. These principal streams have more than two hundred affluents, large and small, which, with countless draws, give the whole country the most perfect drainage. The soil of these high, rolling prairies is mainly a rich alluvium, and is adapted, with favorable climatic conditions, to all forms of vegetation produced in this latitude.

The meteorological conditions are important, and should be carefully studied. I have taken Fort Hays, as affording about an average of meteorological conditions. The fort is in latitude 38° 59′, longitude 99°, with an altitude of 2,107 feet above the sea. The mean rainfall at the fort for the last five years is between nineteen and twenty inches. The mean temperature is about 54°. The maximum temperature remembered is 110°, on July 20, 1881, with a south wind estimated at 70 miles an hour. The high wind driven upon the thermometer evidently affected it, as by the direct heat of the sun. The minimum temperature remembered is 26° below zero, on January 9, 1881.

In western Kansas the great danger lies in extremes. A dry year now and then destroys the crops. A hot wind will sometimes destroy the green corn in a day, wither it up, and cook a green tomato on the vine. When these hot winds come, people shut themselves up in their houses, as they would during a simoon. The grass dries up, still cattle will live on the range; but late crops, such as corn and vegetables, are destroyed. General farming is *precarious*, and the sooner immigrants learn this fact the better. But the country is improving, the rainfall is increasing, and the time is coming when crops in western Kansas will be nearly as certain as in the eastern portion of the State.

The grasses of this region are varied and sufficient for stock purposes. The buffalo grass (*Buchloe dactyloides*), whose roots are very penetrative, extends from the British possessions to Mexico, passing over this region, and has been the sup-

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port of countless numbers of buffalo, deer and antelope in all seasons, and is the support of the animals of the recent settler. Timothy and clover have not so far done well, but blue-grass flourishes. This region is peculiarly well adapted to raising stock. Stockmen are generally doing well, especially those who feed and shelter stock during the winter.

The main cereals of western Kansas are wheat, rye, oats, and sorghum. Corn is beginning to do well. Winter wheat is a staple crop, and the harvest is immense. Sorghum for feeding stock is a growing industry.

At the Post garden at Fort Hays they raise lettuce, radishes, and the early varieties of green peas. The later varieties are exceptional. The early varieties of the eight-rowed corn, yellow and flint, grow well, but the larger varieties and sweet corn are liable to be killed by hot winds. String beans grow occasionally, and early beets and turnips do well. Set onions are very sure. Irish potatoes are occasional, but sweet potatoes are more certain. Salsify does well. The climate is adapted to apples, plums and cherries. Strawberries, once started, bear well; raspberries promise well, but are liable to dry up and be small. Tomatoes are doubtful; early cabbage occasional. Watermelons grow, but muskmelons and squashes are doubtful, on account of insects which prey upon their rough leaves.

Arboreal culture is the most vital question before the people of western Kansas. If one-eighth of the territory could be covered with forests, it would become one of the most productive portions of our country. Forests would make this region a paradise. This question needs to be studied in the light of physical features, soil, rainfall, hot winds, maximum and minimum temperature, and adaptation of vegetable forms to the necessary conditions of the country. We need forests for the wood and shade which they furnish, for the moisture which they precipitate and retain, and for obstructions to the force of winds, which at times render homes and stock uncomfortable, orchards and fruit unsafe, and crops liable to great injury. Abundant forests would undoubtedly prevent the hot winds, which are more destructive to crops than any other thing, and would also have a tendency to drive tornadoes into the upper regions of the atmosphere and render them harmless.

In arboreal culture we have many things to learn. The standard trees of the Eastern States, such as the sugar maple, beech, white and golden willows, larches, firs and spruces do not grow well in western Kansas.

The Osage orange (*Maclura aurantiaca*) is considered one of the best trees for the plains. It protects itself from injury by its thorns, and is a very hardy tree. It bears neglect well, makes a low wind-break, and has no superior as a tree for hedges. It was first found among the Osage Indians, and this fact, together with the fruit, gave it its name. The Indians made their bows of it, and so the French called it *bois d'arc*, or bow-wood, which has been corrupted in the Southwest into "bodock." This tree, in the rich bottom-lands of Texas, sometimes grows sixty feet in height, and from one to two feet in diameter. In western Kansas the Osage orange will attain a height of from fifteen to twenty-five feet. The wood has a fine yellow color, is clear-grained, very hard, strong and elastic. The wood is especially valuable for the wheels of wagons, and takes a fine polish for ornamental work. In its native country the tree when fallen slowly wastes away from the action of the weather, but a decayed tree, I believe, is never found. As a shade tree the Osage orange is rather ornamental, the deep-green leaves displaying their fine tints in the sun, and when the large and abundant oranges are added to the foliage, the tree becomes highly ornamental. This tree needs rich soil, and the seeds should be planted in the spring.

The hackberry (*Celtis occidentalist*) is a very valuable tree for the western plains. It belongs to the nettle family, and is sometimes called the nettle tree. It bears a globular drupe, that is sweet and edible when ripe. The wood is fine-grained and

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compact, but when exposed to the weather it is not very durable. It splits easily, makes good fire-wood, and is sometimes used for rails, and even for baskets. This tree extends from New England to the Pacific, and to Texas on the south, where it grows more abundantly and attains a larger size. Trees there may be found sixty to eighty feet high, with a diameter of from three to five feet. This tree is without enemies, with the exception of the rabbits, which eat the foliage of the young plants. It is quite an ornamental tree, the form being symmetrical, and presents a fine appearance on a lawn. The leaves remain on the tree until late in the fall, when they turn yellow, and all fall almost at once. The tree is hardy, and maintains a vigorous growth amidst all adversities. The seeds should be planted in the fall.

The ash-leaved maple (*Negundo aceroides*), generally known as the box elder, is one of the best trees for the plains. It grows from the Red River of the North to North Carolina, is more abundant westward, and prefers the banks of streams. It is a rapid grower and hardy, but is not long-lived in dry soils. Sometimes it reaches a height in favorable situations of fifty feet, but in western Kansas it is generally smaller. The wood is good for fuel, and the sap yields a beautiful sugar. The tree has a symmetrical growth, a neat habit, and is valued as an ornamental tree. The seeds may be planted in the autumn or in the spring.

The green ash (*Fraxinus viridis*) is an excellent tree for the plains. It gives us our best native wood; but like all good things, is of slow growth. It should be planted on rich land, and the seeds may be sown in the autumn or spring.

The cottonwood (*Populus monilifera*) flourishes from the Alleghany Mountains to the foot-hills of the Rocky Mountains. It grows best along the banks of streams, and in places where the soil is moist. Planted at the base of a hill where it may receive the wash of the ground, it flourishes. It is a very rapid grower, but the wood is soft and not very valuable. It may be grown to supply the earliest necessities of the settler, until better trees of slower growth can be cultivated. It can be propagated from cuttings or seeds.

The black walnut (*Juglans nigra*) is a very valuable tree for the plains. It grows from New England to Florida, but is more abundant in the Mississippi valley, and is much cultivated in western Kansas. It is a large tree, of rapid growth, with a branchless trunk in the forest, but in open ground it spreads out with low branches. The wood is hard, fine-grained and durable, and is susceptible of a fine polish for ornamental purposes. It makes good fire-wood, but has a tendency to "snap." The nuts should be gathered in the fall in heaps, and covered with straw to keep out the rain. In the spring they should be planted where the trees are to stand. Cover the ground with partly rotted straw, and the trees will come through, but the weeds will be kept down.

The red elm (*Ulmus fulva*), known as slippery elm, makes a fair growth of small timber. The white elm (*Ulmus Americana*) grows on low, moist ground. The European elm (*Ulmus campestris*) grows on the public grounds of Leavenworth, I am told, and should be tried on the western plains.

The honey locust (*Gleditschia triacanthus*), known as the three-thorned Acacia, is a good tree for the plains. The seeds may be planted in the fall or spring. The black locust (*Robinia pseudacacia*) does well. It may be propagated by seeds.

The wild (black) cherry (*Prunus serotina*) grows well. It gives a well-known cabinet wood, rivaling black walnut. The seeds may be planted in the fall, or kept mixed with sand, exposed to frost, and planted early in the spring.

The Ailantus (*Ailantus grandulosus*), a Chinese tree, gives good promise. It should not be planted where it is not wanted, as it is a great wanderer. It can be propagated from seeds or cuttings made in the fall, and kept in sand in the cellar, to be planted in the spring.

The red cedar (*Juniperus Virginiana*) is almost the only evergreen that grows well on the plains. It is used largely for ornamental hedges about dwellings, and for wind screens.

Amidst all these varieties of trees, not one forest tree stands related to the necessities of man on the prairies as does the oak in the Eastern and Middle States, and as far west as the great central plains. In the great oak family, Gray gives twenty-three species. On general principles, I believe such a tree exists somewhere in the world —nature has wonderful adaptations. Some flowers blossom in the snow, or very near to it, and some animals live in hot springs. Would it not be a good thing for our Government to look for such a tree in foreign lands? Through its multitudinous correspondents, it could ascertain whether such a tree exists or not. Trees adapted to such a climate as prevails over our western prairies could be thoroughly tested on an experimental farm by experts in tree culture. When the right tree is found, forests could be grown in proper proportion all over the plains, until they are converted into the most productive portion of the continent.

Our prairie world constitutes one-third of the area of the North American continent, and about one-half of its arable land, the cream, I may almost say, of the whole of it. With intelligent treatment, this vast domain may be converted into a veritable paradise, a world in itself, possessing the highest possible environments ever realized by man.

THE NORTHERN SUGAR INDUSTRY AND EXPERIMENT STATIONS.

BY PROF. M. SWENSON.

In order to give you a proper impression of the present state of the Northern sugar industry, I will as briefly as possible review its past history. Previous to 1880 there had been but little attention paid to this industry, except by the United States Department of Agriculture, then in charge of Commissioner LeDuc, who, with his chief chemist, Dr. Peter Collier, was quite irrepressible on the subject of sorghum sugar. The work of the department consisted of an immense number of analyses of different varieties of this plant, and they proved conclusively the presence of large amounts of cane sugar in sorghum juices.

During 1880 in Illinois, and 1881 in Wisconsin, practical experiments were instituted, and the results obtained created considerable interest and attention. On the strength of the results obtained in Illinois, the first sorghum sugar factory was built, at Champaign, in that State. This was operated during the season of 1881, and at the prices of the product then in vogue the venture proved profitable, and the business received quite an impulse, and the following season Kansas had three factories in operation; but they had not been running long when the prices of sugar and syrup depreciated to such an extent as to render the business no longer profitable, and those interested began to look about for a remedy. The processes adopted were identical with those used in the South, but owing to the very spongy and loose texture of the sorghum cane, it was found impossible to get more than about forty per cent. of juice with the heaviest and most modern crushers. The average amount of juice in the cane was found to be about ninety per cent., so that over half the sugar was lost in the first operation, and fully ten per cent. of that obtained was lost in the subsequent treatment of the juice.

The problem, therefore, of obtaining a greater yield of juice was considered by all the most important, and efforts were made to try the process of diffusion, which is the same as that so successfully applied to the sugar beets. This would require a very large outlay of money, and Congress was induced to take hold of the matter, and a bill appropriating $50,000 to this end was passed. Gen. Loring, then Commissioner of Agriculture, having opposed the bill, defeated its object by spending $40,000 of the appropriation for sorghum seed, for which he paid an enormous price, and which was left to spoil in the department seed house. With the remaining $10,000 a diffusion battery, of the most antique pattern obtainable, was built and operated at Ottawa, Kansas, in connection with the Franklin Sugar Company. Although this battery proved entirely unfit for practical work, it was quite conclusively proven that diffusion would extract practically all the sugar from the cane, the average amount obtained being fully 96 per cent. of the whole, and this, moreover, at an expenditure of steam power not exceeding one-tenth that required to run the crushers. These results were so encouraging that Congress passed another bill, appropriating $100,000, to be divided between experiments in the manufacture of sugar by diffusion from sorghum and sugar cane. As a result, the Parkinson Sugar Company, of Fort Scott, Kansas, was formed, and an agreement was entered into between them and the U. S. Department of Agriculture, by which the latter

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agreed to build and erect the machinery necessary for the extraction and purification of the juice of sorghum cane, while the Parkinson Sugar Company were to grow the crop, erect the buildings, boilers, evaporating apparatus, etc., this being by far the most expensive part of the factory. Owing to delays in building the machinery, and the late arrival of that ordered from abroad, the factory was not ready to start until about the middle of September, some of the cane having then been ripe for fully a month.

The method used for making sugar at this factory may be divided into two distinct processes: one for extracting the juice (diffusion), and the other for purifying the juice (carbonatation.) We will first describe the former. The cane is cut into thin slices not over $\frac{3}{16}$ of an inch thick, by machines which do not differ much in principle from the "Belle City" or "Cycle" ensilage or feed cutters, and the chips, as they are now called, are conveyed to the diffusion battery. This consists of fourteen cylindrical iron vessels about $3\frac{1}{2}$ feet in diameter and $7\frac{1}{2}$ feet deep, each holding about a ton of chips. The bottoms of these vessels are hinged so that they can be thrown wide open, and thus give easy vent to the chips after they have been exhausted. When the bottom is closed, a water-tight joint is made by a circular rubber tube, which is distended between the cell and bottom by water pressure slightly above that in the cell. The success of the diffusion process depends, as its name implies, upon the property, possessed by all soluble crystallizable bodies, of passing readily through the cell wall. It is practically carried out as follows: The cells are filled with chips, then closed tight, and water added through proper pipes. The sugar in the juice of the chips passes out into the water surrounding them, until the per cent. of sugar is the same in both. Water is then again added through a pipe in the top of the cell, and the water, which already contains considerable sugar, is forced by displacement into another cell containing less exhausted chips. There an additional amount of sugar is taken up; the water passes in all, through from eight to ten cells each time, taking up an additional amount of sugar, and when finally drawn out from the last cell, which contains perfectly fresh chips, the water, or the juice, as it is now called, is nearly as rich in sugar as the juice itself.

The chips must be just as free from pieces of leaves and sheaths as possible, as these parts contain a large amount of gums and coloring matters. It has been proposed to accomplish this by first cutting the cane, with the blades on, into pieces about an inch long; then by passing them through a fanning mill the pieces of leaves and sheaths can be blown out, and the clean pieces of cane can be cut into thin slices suitable for diffusion. The difficulty so far has been to make a machine to slice the pieces. Several have been made, but none so far have been successful.

Another difficulty was the inversion of the cane sugar. This was caused by the acids of the cane, together with the heat necessary to quickly produce a complete diffusion. A very large amount of the cane sugar was in this way changed into invert sugar or glucose. After trying different remedies without success, I suggested the use of precipitated carbonate of lime or powdered chalk, and this, by neutralizing the acids without in any way injuring the juice, entirely prevented this loss as tried in a small way.

The process employed for purifying the juice was also the same as that employed for working beet juices in Europe, and is called carbonatation. It consists of adding a very large amount of lime to the juice, and then precipitating this by injecting carbon dioxide, (carbonic acid gas.) The carbonate of lime thus formed is very granular and easily filtered, preventing entirely the clogging up of the filter cloths by the slimy precipitates from the juice. It was found, however, that the large amount of lime used acted chemically on the glucose, and caused the syrup to be

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very dark and bitter. This, together with the great expense, will I think, entirely prevent its adoption.

A much better, simpler and cheaper process, and which promises to be as well adapted to small syrup works as to large sugar factories, has of late been introduced into Louisiana. It consists in making the juice barely neutral with lime, and then adding from 1½ to 2 per cent. of powdered lignite, or brown coal, boiling the whole for a few minutes, and then forcing it through a filter press. The powdered lignite serves a two-fold purpose: First, it supplies the necessary granular material to make the filter cakes porous, and prevents the gummy impurities of the juice from clogging up the filter cloths; but aside from this, it has been found to possess a discolorizing effect fully equal to that of bone-black; moreover, the lignite, after it has served the purposes of a filter, can be burned under the boilers. I learn that this material crops out along the Smoky Hill river, in Ellsworth and adjacent counties, and if this process proves as successful as it promises, it will give rise to another Kansas industry — that of mining this lignite, which now has but little market value.

Although our progress this year has not been as rapid as we hoped, being still in the experimental stage, very much has been accomplished, and never before could we look forward to the development of this great industry with as much assurance as now. We have every reason to believe that hereafter 100 pounds of sugar and 14 gallons of syrup will be about an average yield per ton of sorghum cane; and I should not be surprised if this is considerably exceeded. This, together with 2½ bushels of seed per ton, will no doubt make sorghum the most profitable sugar-producing plant known at the present time.

The problem of extracting the sugar completely and economically has been solved; it remains to find a process which will produce a good product, and this is only a matter of a little more investigation. There is one thing more, however, which remains to be done, and this I hope to impress upon you, for the importance of the work (which I shall more specifically apply to the sorghum cane) is equally applicable to all farm products. I refer to the improvement of the plant itself, and increasing its content of cane sugar. So far, this important subject has received little or no attention, principally due to the fact that private individuals are not able to carry on experiments that require all the equipments and skill of a modern agricultural experiment station. As an illustration of what we may reasonably hope to gain, we can take no more apt example than that of the sugar beet. When first manufactured into sugar it contained less than five per cent. of cane sugar, but by careful nursing, producing different hybrids, and preserving seed only from such as were shown by analyses to contain the greatest per cent. of sugar, the average belts of to-day contain fully 15 per cent., and many as high as 20 per cent., of sugar. This has not been an accident, but it is the legitimate result of intelligent and persistent effort and experiment, and it has given to Europe one of the most profitable, and, from an agricultural standpoint, one of the most important manufacturing enterprises in existence.

But I am aware that my remarks might as well remain unsaid if I were pleading for an experiment station for the sole purpose of experimenting with sorghum cane, eminently wise as this would be. Even our conservative Southern friends are now, partly by private subscription, maintaining an experimental station in Louisiana for the sole purpose of experimenting with sugar cane. But of this there is no need, for all the work that could profitably be done with the cane would occupy but a small portion of the time of the officers of such a station.

Other problems, of even much more vital interest to the farmers and to the country, should be made the subject of careful experimentation. There is no industry to-day that presents such a vast field for scientific work as agriculture. Nature has so abundantly stored our Western soil with the elements needed for plant-food, that we draw upon it as if it were indeed exhaustless, but you all know that this cannot last. We cannot hope to continue to take, annually, millions of bushels of wheat from our soil without soon feeling its effect, and the farmer will soon have to avail himself of all the advantages which modern science can give him. There was a time when the lands of our Eastern States were equally productive, and you all know how they were gradually robbed of their fertility. The rich land of our Southern States was cropped year after year, till now much of it is a barren waste. Right here let me call your attention to one of the grandest triumphs of science as applied to agriculture. By the elaborate investigations of the European experiment stations, extending over many years, it was found just what elements are taken from the soil by our different agricultural plants, and as a direct outcome of this work, what are known as chemical fertilizers have been made, which contain the needed elements, not only in proper proportion, but also in such combination as to render them most available for the growing plant; and it is this which has enabled Europe to give back to her soil even more than its virgin fertility. Some idea of the value and usefulness of these experiment stations may be gained from the fact that there are now nearly one hundred and fifty of them in active operation in Europe, and it is almost entirely due to the work of these experiment stations that we owe our present knowledge of the many and complex laws which govern the growth of plants and animals; and the results of their investigations have enabled the farmers of Europe to use their lands to the best possible advantage, and to feed their animals in the most economical manner.

Our farm products are each year meeting with increased competition in foreign markets, and prices are declining in consequence. This is due very largely to the enormously increased production of South American countries, where a large European immigration is being attracted by the vast area of unoccupied lands, and if this continues, as it no doubt will, the difficulty of finding a market for our surplus products will be increased, and our people will find the problem of making farming profitable, each year growing more difficult. The most effective remedy for this will be to cheapen the cost of production, and to effect this nothing will be more useful than experimental stations.

In addition to these general lines of investigation, everything that can tend to promote agriculture is undertaken, not only for the farmers in general, but for each individually; and whenever a farmer is in need of information regarding any question that occurs to him in connection with his work, he will soon learn to appreciate the great advantage of having a corps of trained specialists at his command. The great loss to farmers occasioned by injurious insects, fungi, (such as rusts, smuts, blights, rots, etc.,) diseases of farm animals, and the loss of a large amount of fodder through improper feeding, could be greatly diminished by the careful and systematic study of capable men. According to the "Preliminary Report" of the Commissioner of Agriculture, the loss caused by fungous growth on corn and wheat alone amounts to the enormous sum of $200,000,000 annually. Why, gentlemen, if $\frac{3}{10}$ of one per cent. ($\frac{3}{1000}$ part) of this loss could be prevented, the amount saved would maintain an agricultural experiment station in every State in the Union.

When we consider that agriculture is the true basis of all our prosperity—that hard times for the farmer means universal depression—it seems to me it is high time that something be done to aid the advancement of agriculture.

NATURAL GAS IN EASTERN KANSAS.

(WITH APPENDIX ON OIL.)

BY ROBERT HAY, U. S. G. S.

The last decade, and notably the last five years, have witnessed the development and use of a new illuminant and a new fuel. This is natural gas — inflammable gas made beneath the earth's surface by natural processes, stored in various receptacles, and rushing forth when these receptacles are pierced by the well-sinker's drill. It is a new thing in its present value and importance; and yet, like many other things of recent discovery or invention, it has in some way been known for ages, and in some manner been made useful to man. It is said that the fire-worshippers of ancient Persia supplied their altars with unceasing flame by gas conveyed through pipes of bamboo, and giving revolving lights from burners laid across the supply pipe in the same way as the revolving water-jets used for sprinkling our city lawns. Natural gases explosively dangerous have been known as long as coal mines have been worked here and in Europe, and gases explosive and suffocative are among the phenomena associated with volcanic eruptions. Burning springs have been known in France for twenty centuries, and in West Virginia and Kentucky from the beginning of settlement. Still, with these suggestions in time past, it was reserved for our century to add the general use of natural gas to the elements of national progress. In 1826, this nation's honored guest, General LaFayette, in passing through Fredonia, N. Y., saw the village illuminated by gas which was obtained from a well close by. This gas had been found and utilized in 1821, and a second well was sunk in 1858, which supplies 200 burners. About the same time as the discovery of gas at Fredonia, a small lighthouse at Barcelona, on Lake Erie, was lighted with the same material; but an early attempt to pipe the gas from Fredonia to Dunkirk for the same purpose was a failure. In 1825 some boys near Wigan, in England, ignited gas which was issuing from one of the disused cannel pits of that coal-field. In 1850 a well sunk on a farm on the borders of Chat Moss, Lancashire, one of the scenes of the elder Stephenson's engineering triumphs, gave out gas which, when ignited, sent a great roaring flame forty feet high. It was only conquered by putting over it a large steam boiler with the ends taken out. The flame then passed to the top of this tube, the lower part of which was now drilled, and small pipes being inserted, the gas was taken to the farmhouse, stables, and barn, and used both for fuel and light. At a later date, gas from the mine was used by one of the large coal companies of the Lancashire coal-field to illuminate the principal passages of their extensive underground works. The writer is not aware of any larger use of natural gas in England. It is probable that there the geologic conditions are not favorable to the storage of it underground, and therefore the English will possibly have little direct benefit from this new fuel.

It was in the oil regions of Pennsylvania that the utility of natural gas began to be observed. Gas and oil go together. Almost every oil well yields some gas, and it early began to be used in lighting the villages around the wells and in raising the steam for the pumping engines, and in some cases the pressure of the gas was used as a substitute for steam in driving the engines. In 1860 it was used at East Liverpool, Ohio, for evaporating brine, and a little later for baking pottery. In 1874, at Gambier, Ohio, it was used for making lamp-black. In the same year it was first used in iron-making at Leechburg, Pa. In 1875 it was piped to the iron works of

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Spang, Chalfant & Co., near Pittsburgh, and has there been used ever since. It began to be used in glass-making at Rochester and Creighton, Pa., in 1883.

In this same year, 1883, gas at high pressure obtained at Murraysville, twelve miles from Pittsburgh, Pa., was piped to the latter city. Then began a revolution in the use of fuel. What before was a cautious, tentative advance, became a furore. Gas at high pressures, from 200 to 600 pounds to the square inch, issued at once from a hundred wells. It was piped for miles, and defying the first efforts to confine it, leaks gave rise to explosions, explosions gave rise to inventions, and perfectly tight joints are now made, and the gas is used in manufactures, for culinary purposes, and for illumination, both domestic and public. New districts have been explored for gas, and now it is piped from Washington county, a distance of over thirty miles, into Pittsburgh. A few figures, which were true last April, will show the enormous proportions which this business has assumed in Pittsburgh and Pennsylvania. There are sixty-six companies in the State, engaged in supplying the new fuel. These have an aggregate capital of $20,878,000. Of these, seventeen are in Pittsburgh, (not including Allegheny City,) with a capital of $12,797,000. The largest of these companies is the Philadelphia, with a capital of $5,000,000. Some statements about this company's business seem almost fabulous, but, being approximately correct, will serve as a basis for comparison, by which to estimate the total gas business of the State. This company has ten miles of 24-inch mains, thirteen miles of 20-inch mains, and a total of pipe in use of not less than 336 miles. It supplies in the two cities, 4,500 dwelling houses, 967 boilers, 500 puddling furnaces, besides giving the heat at oil stills, brick kilns, heating furnaces, glass-houses, ovens, and many other things. They displace *every day* TEN THOUSAND TONS OF COAL by a daily consumption of 182,400,000 cubic feet of gas. If all these figures were multiplied by four, as this company has one-fourth of the capital employed, it would probably be not much in excess of the true showing of the Pennsylvania business in natural gas. But some estimates have put it a little less. Thus it is accepted that there is a daily consumption of 600,000,000 cubic feet. Besides this, there is a waste—unused gas escaping through flumes, burnt or unburnt, into the air—of 100,000,000 cubic feet daily, making a grand total of 255,500,000,000 cubic feet of gas coming from the bowels of the earth in Pennsylvania per annum.

In November, 1884, gas was obtained at Findlay, in Hancock county, Ohio, at a depth of 1,100 feet. Since then Ohio, in its northwestern part, almost rivals western Pennsylvania in its productiveness of gas, one of the wells yielding 12,000,000 cubic feet per day. Wheeling and other places in West Virginia are supplied with natural gas; Indiana has it, New York, Illinois, Colorado, Wyoming, Missouri, and Kansas.

The geological horizons at which gas is found are various. They are, however, substantially the same as those which yield petroleum. The geology of rock gas is the same as that of rock oil. In Pennsylvania the geological range is from the lower part of the coal measures downward into the Devonian formations, a vertical distance of about 3,000 feet. This begins in the Mahoning sandstone, which is 500 feet below the Pittsburgh coal, and reaches downward to the Smethport "oil sand," which is 360 feet below "the great Bradford oil sand." In West Virginia and eastern Ohio the same carboniferous, sub-carboniferous and Devonian strata yield oil and gas, and in places lower Silurian strata are sources of it. In western Ohio a group of formations known as the Waverley series, which may be the analogue of lower sub-carboniferous or Devonian strata, lying below a comparatively small development of sub-carboniferous limestone, has become a source of oil and gas, and some of the sections revealed by wells in the older oil regions appear to be identical with portions of the Waverley series. The greatest source of gas in western Ohio, however, is found in a well-known lower Silurian formation—the Trenton limestone. Geologically, this is the deepest seated of the stores of gas and oil, but the wells at Findlay are not as deep as the Pennsylvania wells. In Wyoming Territory, where it appears that immense stores of oil and gas are about to be developed, the strata yielding the fuel are not Paleozoic at all. They are all much newer. They are Mesozoic strata from the Triassic to the Laramie.

Without exception, the earliest supplies of oil and gas were obtained from beds of sandstone. This led to the adoption of the term "*oil sand*," which is the current designation of the oil beds throughout the oil regions, and the term "*gas sand*" has come to have a similar application. In districts where more than one horizon is productive, they speak of the "*first gas sand*," "*second gas sand*," etc. So fixed is this term that the Trenton limestone is termed a "*gas sand*" and an "*oil sand*." In view of possible future developments from limestone, it is not unlikely that we may substitute sometime the more general terms "*gas rock*" and "*oil rock*" as designations of the productive strata.

Whether limestone or sandstone, the oil or gas rock is porous. In some cases the fuel is held in crevices or cavities, but the main storehouses are *the pores of the rock itself.* It has been proved by experiment that coarse sandstones may hold from one-ninth to one-sixth of their bulk of oil, and those of finer grain from one-twelfth to one-eighteenth.* Fossil-bearing limestone will also absorb large quantities of fluids. It would hold gas to the same extent, and we know that such rocks hold water. The water associated with gas is almost universally salt water. If a bed of sandstone contained gas, oil and other brine, there would be a natural tendency for the gas to be at the top, the oil next and the water below, as they would arrange themselves in a tank or bottle; but owing to the pressure to which they and the containing rock are subject, they are frequently found intermingled. It will be readily seen that the pressure and mixing will be greater as more gas is evolved.

These oil and gas rocks are the reservoirs from which we obtain our supplies of these fluids. But it is not in these rocks that either originates. Petroleum and gas have the same origin. Chemical changes of certain minerals may have contributed, but the great source of these subterranean fluids is certainly found in the decomposition of organic matter—both animal and vegetable—under the great pressure and other conditions of deep-seated rocks. This organic matter was mostly buried in the shales that form so large a part of the earth's crust. The darker-colored shales—the black slate and dark-blue soapstone of the miner—are rich in oil and gas. Under pressure, the shales yield their gas and oil to the porous rock above them, or sometimes beneath them, and the rock becomes the "gas" or "oil sand" which yields its wealth to the drill.

One other condition, however, is essential to the yield of the fluids in quantity. The reservoir must be under an impervious cover. There must be a clay or clay shale over it, that will prevent the fluids escaping and being diffused in other rocks or the atmosphere. The oil rock must be buried below all outcrops of river-bed or cañon. Then as the fluids are evolved in Nature's laboratory, they can be stored in Nature's reservoirs till man invades their loneliness.

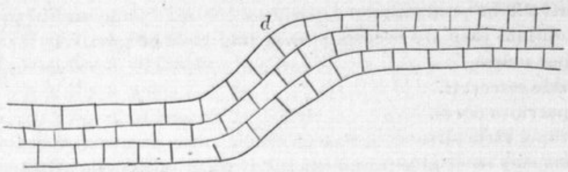
And yet another condition. This is geological structure. The greatest supplies of natural gas have not been obtained where the strata are level. Nor yet are they found where the rock strata are broken by faults and laid almost on edge, as they exist ofttimes on the flanks of mountains. In this latter case all the previous conditions may exist, but the cracks and breaks in the strata would allow the gas to escape as fast as it is formed. Why the gas should not be found in the proper rocks whose horizontality is very little departed from, is not quite so clear; but certain it is that the best gas wells are found in districts or along lines where there is a

*The writer soaked a piece of close-grained, unfossiliferous Permian limestone in coal oil 24 hours; then, allowing it to drain off and wiping it on a cloth, its weight was found to have increased from 103.5 to 104.5 drams (apothecary's), or nearly one per cent.

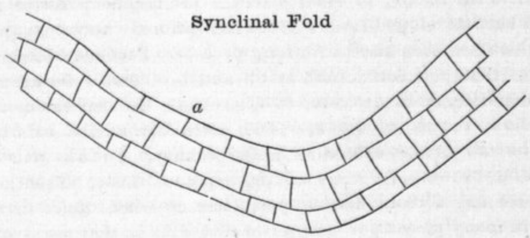
change of dip. A notable example of this is found in the Findlay district in Ohio. The Trenton limestone, approximately level on the east of the town, changes its dip, and plunges down a westerly descent of 165 feet in little over half a mile, to another level floor.

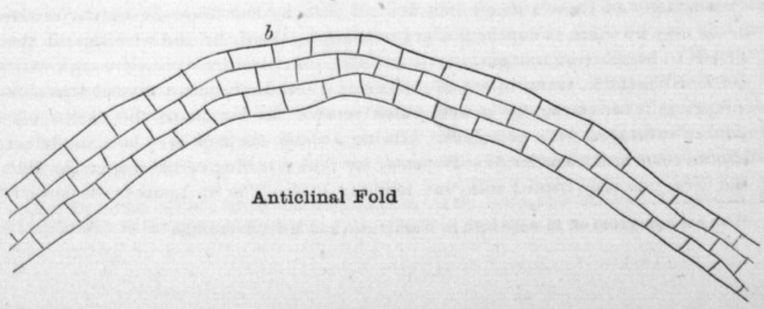
The gas-wells located on the upper terrace, near the change of dip, as at (*d*), yield dry gas. Wells on the upper part of the slope give greater volumes of gas. Those lower down yield oil and brine, with some gas. When the change of dip is double, we have what is called (*a*) a *synclinal* fold, or (*b*) an *anticlinal* fold.

Monoclinal Fold of Strata



Synclinal Fold





Anticlinal Fold

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A question warmly discussed by well-sinkers and geologists has been, "Which of these two forms is most favorable to the yielding of gas?" All the *a priori* reasoning is in favor of what is called the anticlinal theory, and most of the facts observed sustain it. It is also claimed that in cases where gas has been found in synclinal depressions, there is a local modification of the dip, a smaller *anticline within* the synclinal fold, or a subsidiary anticline *crossing* it.

All such folds are of limited extent in one direction, but may have considerable length. Hence they mark out the districts in belts. In some portions of such belts the condition as to source, cover or reservoirs may be defective, and therefore only portions of the belt will be productive.

These four conditions then are necessary to paying yield of gas:

a. A proper source.
b. A suitable reservoir.
c. An impervious cover.
d. The proper structure.

Other conditions *may* enter into the question, but these *must*. As a contribution to the discussion of the theory of structure, we here suggest that the phrases, "amount of dip" and "change of dip," will indicate best the structure that is necessary for the best conditions of gas yield. An anticlinal fold being a double change of dip in a limited distance, the advantages of the two changes are brought within one field.

In this gas question, as in others, Kansas is the *central State*. The geology of her eastern borders touches that of Ohio and Pennsylvania. Her western limits include shales and sandstones that ally her to the oil and gas deposits of Wyoming. Her western counties may yet find in natural gas a native fuel.*

Eastern Kansas is already using natural gas. The history of its development in that region is similar to the history in other places. Gas has been found in prospects for oil, and has been developed from surface indications — actual escapes from the soil or rocks — which has been known for long periods. Professor Mudge, in his report for 1864, states that petroleum, both as oil and bitumen, is found all down the eastern tier of counties, from Atchison to Cherokee. He also saw it in Riley county. Prof. Swallow, in his report for 1865, gives the names of four "tar springs," and says he saw fifteen others in Miami county. For the existence of oil in quantity in Miami county, he sums up the evidence thus: "The facts that scarcely a well has been dug without finding petroleum in some of its forms, that four sandstones are in many places perfectly saturated with it, that more or less of it is found in the cavities of other rocks, and *above all* that it has been flowing from some score of springs from time immemorial, are, to say the least, very strong evidence of the existence of large reservoirs in these localities." Prof. Swallow is unfortunately wrong in regarding the springs as evidence of reservoirs. They are the best of evidence that there is no reservoir. These springs are at the outcrop of the oil-bearing rocks, and tell us that nature has poured out the oil about as fast as it has been made in those rocks which are cut into by the drainage of the district. Still, oil may be there at depths not yet reached by the drill; and with the oil there is certain to be more or less gas.

On Mr. Westfall's farm, in sec. 16, township 17, r. 24, 7½ miles east of Paola, is a "tar spring," and close by a well which pierces the source of the tar or oil, a sandstone saturated with petroleum. Owing to this, borings have been made here, and further east and west, for over 20 years, for oil. A boring of 300 feet on the banks of the Wea, one mile from Paola, was made in 1874. The St. Louis or Ernstein Oil

*Gas has been given off in wells both in Washington and Mitchell counties.

Co. bored two wells ten miles east of Paola in 1865, and lost their tools at a depth of 700 feet. These borings showed some gas. Some borings at Osawatomie in 1865–6 gave brine and some oil. In 1882 a well was bored on the Westfall place, which gave gas in considerable quantity. The driller, Mr. Warner, then formed the Kansas Oil and Mining Company, under an old lease. This has been changed to the Paola Gas Company, of which B. Miller is now the president. This company have a capital of $25,000. They have bored some wells about town, but three wells on the Westfall place are the sources from which they are now supplying gas as an illuminant and fuel to the town of Paola, over seven miles distant. There are four wells, but one yields no gas. Tested by a steam gauge, the gas had the following pressures:

Well No. 1, 66 lbs. to the square inch.
Well No. 2, 66 lbs. " " "
Well No. 3, none.
Well No. 4, 55 lbs. " " "

Another well, nearer town, (Boone's,) gave a pressure of 40 pounds. These pressures, it will be seen, are very much below those recorded for the great wells of Pennsylvania and Ohio; but it is a very useful pressure, and the wells yielding it are capable of supplying a vast amount of fuel and light. The heating qualities of this gas are very great, but as an illuminant so far it is not quite as good as the better kinds of artificial gas.* Another company (the Wea Coal, Oil and Gas Co.) is now engaged in drilling near Paola; and one of the members of it (Mr. W. G. Oakman) owns a well at Beavertown, five miles east of Paola, which yields considerable gas at a depth of only 76 feet. The depths at which gas is obtained in the wells on the Westfall place are:

Well No. 1, 304 feet to top of "gas sand."
Well No. 2, 300 " " "
Well No. 3, 288 " " "

No. 1 penetrated the "sand" 10 feet. No. 2 went through it (35 feet) and went farther, to a total depth of 442 feet, without finding more gas. No. 3 found the gas sand intercalated in thin strata with "slate," and the gas in very small quantity. The wells are all on the same quarter-section, and are at approximately the same level. In No. 1 the well is cased to a depth of 200 feet, and in No. 2 to a depth of 235 feet. No. 2 has a good supply of brine, which it is intended to utilize in the manufacture of salt. Nos. 1, 2 and 4 are almost in a straight line—the distance from 1 to 2 being 1,300 feet west by south, and No. 4 100 feet from 2, in the direction of 1. An examination of the drill records of these wells shows considerable differences in the strata, after allowing for possible errors.

At the small town of Louisburg, in Miami county, a gas well supplies gas from a depth of three hundred and twenty-five feet to light and heat a small hotel.

Fort Scott, in Bourbon county, has this year begun the use of natural gas, and has "struck oil" in a well yielding four barrels per day. Southwest of that town, on the banks of the Marmaton river, gas has been escaping for at least a quarter of a century. The Fort Scott Economy Fuel Co., of which Major Knapp is the energetic superintendent, has leased land from the proprietor, Mr. Stuart, and has drilled four wells, three of which are yielding an abundant supply of gas. The three productive wells form the apices of a triangle nearly equilateral, whose sides are just under 700 feet in length. The distance from town is little, as the farm abuts on the city boundaries. Mains have been laid, and the gas is now in use in Fort Scott hotels, private houses, car-barns, &c. In these wells, a gas horizon is found at about

* The gas is used in Paola for heating steam boilers, bakers' ovens, heating-stoves, cook-stoves, and for illumination in the stores of the city.

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100 feet below the first limestone, which shows itself in the bed of the Marmaton; but the main supply is from a bed of sandstone, which is reached in the different wells at from 175 to 195 feet below the limestone horizon mentioned. In well No. 3, only gas of the upper "sand" was obtained, and that in small quantity. In well No. 4, the gas of the upper sand is much greater in quantity, and the main gas is also stronger. The lower gas sand in well No. 1 was passed entirely through, showing a thickness of 42 feet, and below it forty feet of shales and "black slate," with three seams of coal, were found. The artesian well at Fort Scott — 621 feet deep — yields considerable gas with sulphurous odor, and the record shows a sandstone at about the same depth as in the other wells. The record of a well on the Plaza Point, in the city, shows an oil-bearing sandstone some 80 feet lower. A deep boring — the Brickley well, two miles east by south from the Stuart wells — shows a sandstone in about the same position, but divided into parts by an intercalation of shale. The record makes no mention of oil or gas. A shallow well (110 feet) in the eastern part of the city, is blowing off gas bubbling with water; this from a much higher horizon than the gas wells proper. Five miles west of Fort Scott, on the north side of the Marmaton, the striking of gas in a school well caused the driller to abandon his work at about 75 feet of depth. The oil-well record, just east of the city, shows a sand about the same as the gas wells, but the oil is obtained at a depth of 400 feet.

At Wyandotte, or in what is now Kansas City, Kansas, there are three wells of which the gas is being utilized — one at a flour mill, one at a planing mill, and one at the pressed-brick works. At the two former the gas is turned into the furnace under the steam boiler, and is estimated to save from 10 to 20 per cent. of the coal. At the brick works it is used in the same way, and saves 90 per cent. of the coal. Another well at Wyandotte* is blowing off gas and some oil, which are not utilized at all. The drill records of these wells appear to be lost.

Two miles east and half a mile south from LaCygne, in Linn county, on the east bank of Middle creek, gas has exuded from the ground for generations. Indian pow-wows were held around its flame. The land has been leased by Mr. McCarthy, of LaCygne, and a well 180 feet deep has been drilled, from which gas is obtained, sending a flame twenty feet high. Concessions have been obtained from the city of LaCygne, but want of capital has so far hindered the use of this gas, and tens of thousands of cubic feet are daily wasted in the air. At Mound City, in the same county, a gas well 125 feet deep has been in existence since 1881. The brine from it is drunk as a mineral water, but the gas is not utilized. Another well is now being drilled, for the purpose of obtaining gas. Drilling has also been done at Pleasanton.

The well-known mineral well at Iola, in Allen county, yields gas from a crevice in black shale just below an oil-bearing limestone, at a depth of 628 feet. For some time this was used in a heating-stove in the hotel, but the floods of last year came over the top of the well and diminished the supply, and the small quantity now issuing is allowed to escape unused. Another well is being drilled now, prospecting for gas at Iola. Four and a half miles north and one mile west of Moran, in the same county, is a well yielding gas at a depth of 103 feet. It is not utilized.

In Crawford county gas has been obtained in the deep well owned by the city of Girard, but it has not been put to any use. A well over 400 feet deep at Mound Valley, Labette county, is giving out considerable quantities of gas. Its force is sufficient to hold the column of salt water up to the surface, where it flows like an artesian well. Owing to doubts about the title, this is being allowed to run to waste.

The mineral well, 1,000 feet deep, at Independence, in Montgomery county, yielded gas from a black shale, at a depth of 425 feet. A boring at Liberty, in the same

*See "Appendix on Oil."