THE CEREALS.

GENERAL STATEMENT OF CEREAL PRODUCTION IN THE UNITED STATES.

GRAIN PRODUCTION IN THE UNITED STATES.

The total production of the six principal cereal grains in the United States for the census year amounts to 2,697,962,456 bushels, an average of 53.8 bushels per head for the whole population. The total breadth of cultivation and the amount of product of each of the grains is as follows:

TABLE I.

Grain.	Acres.	Production.
		Bushels.
Corn	62, 368, 869	1, 754, 861, 535
Wheat	35, 430, 052	459, 479, 505
Oats	16, 144, 593	407, 858, 999
Barley	1, 997, 717	44, 113, 495
Rye	1, 842, 303	19, 831, 595
Buckwheat	848, 389	11, 817, 327
Total	118, 631, 923	2, 697, 962, 456

Whether considered in respect to breadth of cultivation, total product, or average production per head of the whole population, these figures place the United States at the head of the grain-producing countries of the world. The cereal production of this country by decades since 1850, as shown by the census enumerations, along with the percentages of increase by decades, the percentage of increase since 1850, and the product per head at each enumeration, is exhibited in the following table:

TABLE II.

Decades ending—	Total cereal production in the United States.	Percentage of increase since 1850.	Percentage of increase by decades.	Amount per capita of total population.
	Bushels.			*Bushels.*
1880	2, 697, 962, 456	211. 0	94. 5	53. 79
1870	1, 387, 299, 153	59. 9	12. 0	35. 98
1860	1, 239, 039, 947	42. 8	42. 8	39. 40
1850	867, 453, 967	....	....	37. 40

The preceding table shows that the increase is both actual as to quantity and relative as to population. The tables of cereal production, taken in connection with the tables of other production, and these compared with the returns of previous census years, show that agriculture continues to be the leading productive industry of the country, and cereal production the most prominent feature of this industry. Indeed, the greatness of our total agricultural production, and more particularly the overflowing abundance of our breadstuffs and food products, are the features of our material wealth and progress which are now most prominently before the world.

The increase in grain production since the previous census enumeration is in part due to the cultivation of new lands in the West and in the Northwest, but more largely due to gain in farming regions already occupied in 1870. The popular belief that the chief increase in production and the rapid growth of grain exports is due to the cropping of new and cheap lands is not sustained by the census enumeration. The tables of production show that the most of the gain is in regions some time in cultivation, and on lands ranging in value from $30 per acre upward.

GRAIN PRODUCTION ELSEWHERE.

The following table gives the estimates by two eminent authorities of the amounts of grain produced by the respective countries named.

The first column, from Kolb (*The Condition of Nations*, page 906), is Dr. Neumann's estimate of "The total yield of corn (grain) in average harvests". It was prepared about 1877.

The second column is the estimate by Mulhall, as shown in his tables of the food supply of the world (*Balance Sheet of the World for Ten Years*, 1870 *to* 1880, page 38). His estimate is larger than Dr. Neumann's, but this is in part accounted for by his reduction of potatoes to terms of grain. He says: "Of course all kinds of grain are included, as even what is used for cattle serves ultimately to produce food for the population. Potatoes are counted for grain on the ordinary estimate of four bushels being equal to one of wheat."

TABLE III.—ESTIMATED GRAIN PRODUCTION.

	Estimated by Neumann.	Estimated by Mulhall.
	Bushels.	*Bushels.*
Austria	....	560,000,000
Austria-Hungary	547,488,800	....
Belgium	74,282,400	95,000,000
Denmark	82,608,000	74,000,000
France	541,986,400	740,000,000
Germany	715,312,000	950,000,000
Great Britain	365,909,600	410,000,000
Greece	8,260,800	....
Holland	27,512,000	50,000,000
Italy	189,976,800	270,000,000
Norway and Sweden	82,608,000	78,000,000
Portugal	31,063,200	30,000,000
Roumania	132,057,600	....
Russia	1,540,672,000	1,020,000,000
Servia	13,768,000	....
Spain	143,062,400	305,000,000
Switzerland	19,258,400	....
Turkey (European)	129,306,400	....
Turkey, Greece, etc	....	90,000,000
Australia	....	58,000,000
Algeria	....	20,000,000
Canada	107,296,800	170,000,000
United States	1,568,184,000	2,390,000,000

The statements in the above table, although not agreeing very closely, and underrating American production as they do, are taken as the estimates of two eminent statistical writers, and are perhaps as reliable as any other estimates. It is believed that the harvests of Europe for 1878 were, as a whole, 2 or 3 per cent. above the averages given by Neumann, and the harvests of 1879 considerably below. In America, however, in the latter year, the harvests were considerably above the average. It is probable that one reason why the production of the United States has been so largely underrated is because the crop of Indian corn has been underestimated. Of the above countries of Europe, as given in the table by Mulhall, Russia, Austria, Spain, and Denmark, with Turkey and Greece, produce a surplus which he estimates at 237,000,000 bushels, while in the remaining countries of Europe there is a deficit of 617,000,000 bushels, equivalent to a deficit throughout Europe of 380,000,000 bushels.

Of this by far the largest is in Great Britain, where he estimates the deficit at 280,000,000; next in France, 170,000,000; and in Germany, 115,000,000. He states, moreover, that about 200,000,000 bushels of wheat are grown in India, of which about one-tenth is exported. Intimately connected with this table is Mulhall's estimate that there is a deficit in the meat production of Europe amounting to 853,000,000 pounds, which occurs in the same countries wherein there is a deficit in grain production.

GRAIN CONSUMPTION PER HEAD OF POPULATION.

According to a great natural law, the greater the production of any food product in any country the greater will be its consumption, and consequently the United States is doubtless the best-fed nation in the world. The amount of consumption of grain per head is variously estimated by different political economists.

The production and consumption of grain per head of total population is estimated by Mulhall (*Balance Sheet of the World*, p. 39) as follows:

TABLE IV.

	Production. *Bushels.*	Consumption. *Bushels.*
Austria	14.35	13.57
Denmark	36.80	30.83
France	19.94	24.02
Germany	21.15	23.71
Great Britain	11.90	20.02
Holland	12.50	16.25
Italy	9.45	9.62
Russia	20.22	17.97
Spain	17.98	17.68
Europe	16.50	17.66
Canada	40.30	38.11
United States	48.10	40.66

CEREAL EXPORTS.

The large actual production of 53.8 bushels per head of total population shows that the United States must be a grain-exporting country, notwithstanding the enormously large consumption by its population. The grain and flour exports for the five years ending June 30, 1880, amount as follows:

Wheat and corn	bushels..	833,692,207
Flour and corn meal	do....	24,850,316
Total value	dollars..	892,788,117

But this by no means shows the exporting value of the grain crops during that period. The shipments of live animals, which had scarcely begun at its beginning, had assumed larger proportions at its end, the aggregate amounting to 1,720,249 head, of the value of $33,796,493.

In addition to this the exports of fresh and salted beef, fresh mutton, pork, bacon, hams, and lard, amounted to 5,139,211,972 pounds, which, with the preserved meats (the quantity of which is not stated), amount in value to $461,255,886. These, with the export of 20,562,387 gallons of spirits made from grain, foot up an aggregate value of $1,394,136,333.

It is impossible to reduce all of these exports to terms of grain, the meat product being the combined production of green and grain crops. Moreover, various manufactured products are related more or less directly to our grain supply, such as starch, glucose, lard-oil, and glycerine.

And again, the increase of grain-growing in one portion of the country, and the facilities for its transportation to another, profoundly affect the cultivation of other commercial plants. The tobacco crop of Kentucky and the cotton crop of the Gulf states are increased by the grain production of Illinois and Ohio. Therefore the tables of grain exports do not show the whole exporting value of the crop.

The tables of grain and flour exports from the country have been compiled and prepared by Mr. J. R. Dodge, and have been made as full as possible, not only to show the recent transactions, but to illustrate the history and growth of the movement.

To these is appended a table of the aggregate quantities and values exported in five years of live animals, meat products, and spirits, which are intimately related to the grain product.

Table V.—Exports of breadstuffs from 1790 to 1816, inclusive.

Year ending September 30—	Wheat.	Flour.	Rye.	Rye meal.	Barley.	Indian corn.	Corn meal.	Oats.	Oat meal.	Buckwheat.	Buckwheat meal.
	Bushels.	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*
1790	1,124,458	724,623	21,765	...	...	2,102,137	99,973	98,842	...	7,562	423
1791	1,018,339	619,681	36,737	24,062	35	1,713,241	70,330	116,634	6	14,499	265
1792	853,790	824,464	12,727	14,126	...	1,964,973	52,681	119,733	...	1,961	146
1793	1,450,575	1,073,498	1,305	12,695	30	1,226,072	37,943	78,524	...	330	361
1794	696,797	828,405	696	4,034	26	1,472,700	48,834	55,003	...	346	...
1795	141,273	687,369	703	4,882	...	1,935,345	102,529	64,335	...	678	*a*1,076
1796	31,226	725,194	4,319	*a*152,784	345	1,173,552	*a*540,286	59,707	...	33	*a*216
1797	15,655	515,633	1,331	*a*36,570	479	804,922	*a*254,799	38,221	*a*3,880	136	*a*84
1798	15,021	567,558	2,721	*a*48,444	4,066	1,218,231	*a*211,694	46,475	*a*2,000	27	...
1799	10,056	519,265	1,595	*a*49,269	552	1,200,492	*a*231,226	57,359	*a*200	754	*a*93
1800	26,853	653,052	8,227	*a*79,077	432	1,694,327	*a*338,108	57,306	*a*1,637	851	*a*1,907
1801	239,929	1,102,444	31,110	*a*392,276	8,796	1,768,162	*a*919,355	100,544	*a*347	154	*a*3,260
1802	280,281	1,156,248	2,492	*a*33,202	485	1,633,283	*a*266,816	70,778	...	1,099	239
1803	686,415	1,311,853	50,753	28,273	2,745	2,079,608	133,606	84,407	...	94	48
1804	127,024	810,008	11,715	21,779	5,318	1,944,873	111,327	73,726	1	2	98
1805	18,041	777,513	1,474	23,455	7,185	861,501	116,131	55,400	...	90	124
1806	86,784	782,724	614	18,090	156	1,064,263	108,342	60,903	...	25	30
1807	1,173,114	1,249,819	6,650	29,067	4,893	612,421	136,460	65,277	...	66	65
1808	87,330	263,813	530	6,167	173	249,532	30,818	23,698	...	...	...
1809	393,890	846,247	1,185	1,306	200	522,074	57,260	20,861	...	60	1
1810	325,924	798,431	448	5,078	6,942	1,054,252	86,744	44,425	...	73	180
1811	216,833	1,445,012	14,818	29,375	29,716	2,790,850	147,425	211,894	4	150	...
1812	53,832	1,443,492	82,705	69,839	49,707	2,039,999	90,810	48,469	...	...	1
1813	288,535	1,260,943	140,136	65,680	...	1,486,970	58,521	14,105	...	...	...
1814	...	193,274	...	2,716	2,300	61,284	26,438	6,046	...	...	...
1815	17,634	862,739	831	6,016	2,237	830,516	72,364	29,899	...	180	202
1816	52,321	729,053	3,464	8,373	6,858	1,077,614	89,119	45,830	...	20	57

a Quantities stated in bushels.

Table VI.—Exports of breadstuffs from 1817 to 1862, inclusive.

Year ending September 30—	Wheat.		Wheat flour.		Indian corn.		Corn meal.		Rye flour.		Barley, oats, rye, etc.	
	Bushels.	Dollars.	Barrels.	Dollars.	Bushels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars.	Bushels.	Dollars.
1817	96,407	216,916	1,479,198	17,751,376	387,454	581,181	106,763	747,341	78,067	624,536	78,649	53,375
1818	196,808	393,616	1,157,697	11,576,970	1,075,190	1,075,190	120,029	660,215	107,335	592,343	136,242	93,442
1819	82,065	103,581	750,660	6,005,280	1,086 762	815,072	135,271	608,720	48,388	241,940	93,936	68,773
1820	22,137	16,603	1,177,036	5,296,664	533,741	330,919	146,316	512,106	37,014	129,549	31,661	12,747
1821	25,821	20,925	1,056,119	4,298,043	607,277	261,099	131,669	345,180	23,523	55,226	...	47,137
1822	4,418	3,080	827,865	5,103,280	509,098	378,427	148,228	522,229	19,971	75,736	...	63,832
1823	4,272	5,663	756,702	4,962,373	749,034	453,622	141,501	476,807	25,665	91,957	...	89,354
1824	20,373	20,740	996,792	5,759,176	779,297	351,665	152,723	384,675	31,879	85,651	...	95,401
1825	17,990	18,570	813,906	4,212,127	869,644	429,906	187,285	448,167	29,545	73,245	...	92,226
1826	45,166	38,676	857,820	4,121,466	505,381	384,955	158,652	622,366	14,472	49,297	...	72,371
1827	22,182	14,800	868,492	4,420,081	978,664	588,462	131,041	434,002	13,345	47,696	...	87,284
1828	8,906	6,730	860,809	4,286,939	704,902	342,824	174,639	480,034	22,214	59,036	...	67,997
1829	4,007	6,372	837,385	5,793,651	897,656	478,862	173,775	495,673	34,191	127,004	...	74,896
1830	45,289	46,176	1,227,434	6,085,953	444,107	224,823	145,201	372,296	26,298	87,796	...	66,249
1831	408,910	523,270	1,806,529	9,938,458	571,312	396,617	207,604	595,434	19,100	71,881	...	132,717
1832	88,304	93,500	864,919	4,880,623	451,230	278,740	146,710	480,035	17,254	75,392	...	78,447
1833	32,221	29,592	955,768	5,613,010	487,174	337,505	146,678	534,309	36,038	140,017	...	102,568
1834	36,948	39,598	835,352	4,520,781	303,449	203,573	149,609	491,910	39,151	140,306	...	49,465
1835	47,762	51,405	779,396	4,394,777	753,781	588,276	166,782	629,389	30,854	129,140	...	96,478
1836	2,062	2,062	505,400	3,572,599	124,791	103,702	140,917	621,560	36,646	173,976	...	80,492

TABLE VI.—EXPORTS OF BREADSTUFFS FROM 1817 TO 1862, INCLUSIVE—Continued.

Year ending September 30—	Wheat.		Wheat flour.		Indian corn.		Corn meal.		Rye flour.		Barley, oats, rye, etc.	
	Bushels.	Dollars.	Barrels.	Dollars.	Bushels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars	Bushels.	Dollars.
1837	17, 303	27, 206	318, 710	2, 987, 200	151, 276	147, 982	159, 435	763, 652	28, 323	165, 457	....	80, 785
1838	6, 291	8, 125	448, 161	3, 603, 299	172, 321	141, 992	171, 843	722, 399	22, 804	110, 702	....	94, 533
1839	96, 325	144, 191	923, 151	6, 925, 170	162, 306	141, 095	165, 672	658, 421	29, 458	145, 448	....	72, 050
1840	1, 720, 860	1, 635, 483	1, 897, 501	10, 143, 615	574, 279	338, 333	206, 063	705, 183	53, 218	170, 931	....	113, 393
1841	868, 585	822, 881	1, 515, 817	7, 759, 646	535, 727	312, 954	232, 284	682, 457	44, 031	138, 505	....	159, 893
1842	817, 958	916, 616	1, 283, 602	7, 375, 356	600, 308	345, 150	209, 199	617, 817	84, 190	124, 396	....	175, 082
1843	311, 685	264, 109	841, 474	3, 763, 073	672, 608	281, 749	174, 354	454, 166	21, 770	65, 631	....	108, 640
1844	558, 917	500, 400	1, 438, 574	6, 759, 488	825, 282	404, 008	247, 882	641, 029	32, 690	104, 301	....	133, 477
1845	389, 716	336, 779	1, 195, 230	5, 398, 593	840, 184	411, 741	269, 030	641, 552	35, 371	112, 908	....	177, 053
1846	1, 613, 795	1, 681, 975	2, 289, 476	11, 668, 669	1, 826, 068	1, 186, 663	298, 790	945, 081	38, 530	138, 110	....	638, 821
1847	4, 399, 951	6, 049, 350	4, 382, 496	26, 133, 811	16, 326, 050	14, 395, 212	948, 060	4, 301, 334	48, 892	225, 502	....	1, 600, 962
1848	2, 034, 704	2, 669, 175	2, 119, 393	13, 194, 109	5, 817, 634	3, 837, 483	582, 339	1, 807, 601	41, 584	174, 506	....	376, 572
1849	1, 527, 534	1, 756, 848	2, 108, 013	11, 280, 582	13, 257, 309	7, 966, 369	405, 169	1, 169, 625	64, 830	218, 248	....	139, 703
1850	608, 661	643, 745	1, 385, 448	7, 098, 570	6, 595, 092	3, 892, 193	259, 442	760, 611	69, 903	216, 076	....	121, 191
1851	1, 026, 725	1, 025, 732	2, 202, 335	10, 524, 331	3, 426, 811	1, 762, 549	203, 622	622, 866	44, 152	146, 802	....	120, 670
1852	2, 694, 540	2, 555, 209	2, 799, 339	11, 869, 143	2, 627, 075	1, 540, 225	181, 105	574, 380	18, 524	64, 476	....	334, 471
1853	3, 890, 141	4, 354, 403	2, 920, 918	14, 783, 394	2, 274, 909	1, 374, 077	212, 118	769, 974	8, 910	34, 186	....	165, 824
1854	8, 036, 665	12, 420, 172	4, 022, 386	27, 701, 444	7, 768, 816	6, 074, 277	257, 403	1, 002, 976	23, 624	112, 703	....	570, 195
1855	798, 884	1, 329, 246	1, 204, 540	10, 896, 908	7, 807, 585	6, 961, 571	267, 208	1, 237, 122	85, 304	236, 248	....	238, 976
1856	8, 154, 877	15, 115, 661	3, 510, 626	29, 275, 148	10, 292, 280	7, 622, 565	293, 607	1, 175, 688	38, 105	214, 503	....	2, 718, 620
1857	14, 570, 331	22, 240, 857	3, 712, 053	25, 882, 316	7, 505, 318	5, 184, 666	267, 504	957, 791	27, 023	115, 828	....	680, 108
1858	8, 926, 196	9, 061, 504	3, 512, 169	19, 328, 884	4, 766, 145	3, 259, 039	237, 637	877, 692	14, 283	56, 235	....	642, 764
1859	3, 002, 016	2, 849, 192	2, 431, 824	14, 433, 591	1, 719, 998	1, 323, 103	258, 885	994, 269	14, 432	60, 786	....	1, 181, 170
1860	4, 155, 153	4, 076, 704	2, 611, 596	15, 448, 507	3, 314, 155	2, 399, 808	233, 709	912, 075	11, 432	48, 172	....	1, 058, 304
1861	31, 238, 057	38, 313, 624	4, 323, 756	24, 645, 849	10, 678, 244	6, 890, 865	203, 313	692, 003	14, 143	55, 761	....	1, 124, 556
1862	37, 289, 572	42, 573, 295	4, 882, 033	27, 534, 677	18, 904, 909	10, 387, 383	253, 570	778, 844	14, 463	54, 488	....	2, 364, 625

TABLE VII.—QUANTITY AND VALUE OF WHEAT OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1860 TO 1880, INCLUSIVE.

Year ending June 30—	Countries to which exported.							Total quantity.	Total value.
	Great Britain and Ireland.	Germany.	France.	Belgium.	Portugal.	British America.	Other countries.		
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Dollars.*
1860	1, 934, 206	....	28, 495	8, 052	5, 730	1, 189, 506	989, 065	4, 155, 153	4, 076, 704
1861	24, 510, 961	46, 019	1, 728, 190	160, 408	25, 080	4, 167, 915	599, 475	31, 238, 057	38, 313, 624
1862	22, 905, 505	46, 017	7, 813, 565	1, 036, 735	327, 070	4, 552, 220	608, 460	37, 289, 572	42, 573, 295
1863	27, 325, 739	38, 479	403, 679	622, 986	583, 083	6, 583, 695	602, 763	36, 160, 414	46, 754, 195
1864	18, 078, 999	99, 627	202, 424	78, 270	82, 104	4, 116, 543	693, 545	23, 681, 712	31, 432, 133
1865	5, 823, 255	....	17, 329	85, 885	90, 282	3, 762, 591	157, 810	9, 937, 152	19, 397, 197
1866	1, 970, 716	....	....	....	83, 794	1, 925, 693	1, 598, 900	5, 579, 103	7, 842, 749
1867	4, 685, 615	....	41, 436	....	4, 800	811, 302	603, 168	6, 146, 411	7, 822, 555
1868	12, 368, 446	....	260, 763	34, 726	83, 198	3, 069, 153	124, 621	15, 940, 899	30, 247, 632
1869	13, 356, 550	21, 961	86, 839	5, 016	120, 880	3, 383, 277	633, 313	17, 557, 836	24, 383, 259
1870	27, 787, 609	317, 289	1, 012, 637	195, 904	701, 825	6, 259, 133	309, 658	36, 584, 115	47, 171, 229
1871	22, 488, 021	149, 214	555, 263	942, 309	475, 856	9, 340, 178	353, 975	34, 310, 906	45, 143, 424
1872	19, 017, 411	290, 737	1, 429, 088	1, 275, 101	426, 884	3, 711, 542	271, 717	26, 423, 080	38, 915, 060
1873	31, 790, 876	164, 474	....	100, 054	131, 120	6, 306, 840	710, 912	39, 204, 285	51, 452, 254
1874	51, 833, 278	886, 485	2, 223, 366	3, 709, 694	300, 301	8, 721, 303	3, 365, 501	71, 039, 928	101, 421, 459
1875	42, 057, 004	373, 818	127, 000	2, 081, 744	1, 595, 014	5, 032, 981	1, 779, 607	53, 047, 177	59, 607, 863
1876	42, 256, 052	516, 156	521, 041	2, 190, 282	1, 412, 988	5, 530, 637	2, 645, 366	55, 073, 122	68, 382, 899
1877	31, 202, 296	990, 067	874, 642	1, 410, 610	1, 013, 302	4, 142, 424	692, 270	40, 325, 611	47, 135, 562
1878	54, 664, 732	33, 573	4, 337, 001	3, 633, 778	2, 178, 366	5, 670, 107	1, 878, 314	72, 404, 961	96, 872, 016
1879	57, 419, 292	422, 242	42, 147, 558	9, 037, 297	3, 174, 611	5, 204, 033	4, 948, 903	122, 353, 936	130, 701, 079
1880	79, 068, 075	1, 223, 279	43, 601, 291	13, 418, 016	2, 196, 724	7, 920, 248	5, 825, 162	153, 252, 795	190, 546, 305

TABLE VIII.—QUANTITIES OF WHEAT OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1862 TO 1880, INCLUSIVE.

Years.	Ports from which exported.									Total.
	New York.	Boston.	Philadelphia.	Baltimore.	New Orleans.	Chicago.	Milwaukee.	San Francisco.	All other.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1862	28, 104, 870	5, 080	2, 210, 776	531, 137	....	1, 987, 276	1, 567, 657	1, 530, 835	1, 282, 023	37, 289, 572
1863	25, 936, 155	1, 483	1, 500, 632	411, 856	....	1, 519, 396	2, 880, 701	1, 777, 213	2, 112, 888	36, 160, 414
1864	17, 294, 391	....	447, 003	66, 583	1, 050	1, 274, 703	2, 152, 681	1, 793, 196	652, 105	23, 681, 712
1865	5, 518, 937	897	202, 404	2, 766	....	1, 576, 996	1, 426, 491	46, 141	1, 162, 520	9, 937, 152
1866 (a)	....	....	....	....	....	....	....	....	....	....
1867 (a)	....	....	....	....	....	....	....	....	....	....
1868	7, 208, 373	1, 397	79, 764	10, 769	31, 830	1, 090, 810	1, 288, 608	5, 542, 303	78, 045	15, 940, 899
1869	8, 379, 924	....	43, 099	8, 348	168, 833	1, 775, 836	1, 373, 776	5, 530, 624	277, 396	17, 557, 836
1870	20, 077, 434	....	988, 390	820, 931	398, 862	1, 933, 314	2, 322, 317	7, 939, 030	2, 103, 837	36, 584, 115
1871	18, 090, 794	81, 914	383, 686	263, 743	12, 510	3, 703, 134	4, 483, 011	5, 903, 427	1, 382, 687	34, 304, 906
1872	17, 880, 037	134, 581	1, 168, 102	906, 353	....	856, 764	1, 148, 720	2, 263, 085	2, 050, 438	26, 423, 080
1873	15, 095, 260	176, 865	508, 174	221, 743	....	3, 517, 981	2, 342, 317	15, 906, 162	1, 345, 783	39, 204, 285
1874	41, 482, 167	851, 788	3, 596, 072	2, 932, 364	262, 959	4, 804, 972	3, 064, 633	11, 514, 578	2, 530, 395	71, 039, 928
1875	24, 7[illegible]2, 063	636, 040	2, 812, 451	2, 975, 266	140, 847	2, 298, 465	1, 233, 483	14, 469, 958	3, 747, 795	53, 047, 177
1876	31, 431, 183	391, 051	3, 652, 143	1, 309, 524	140, 623	1, 821, 801	2, 187, 693	9, 093, 231	4, 444, 073	55, 073, 122
1877	13, 561, 751	170, 932	1, 426, 193	1, 548, 676	163, 229	1, 343, 333	1, 227, 412	16, 840, 184	4, 004, 901	40, 325, 611
1878	39, 101, 511	2, 941, 669	4, 575, 561	8, 726, 507	839, 798	1, 734, 032	1, 826, 939	6, 027, 337	6, 031, 607	72, 404, 961
1879	55, 485, 183	3, 499, 571	13, 247, 236	23, 569, 960	1, 644, 072	1, 269, 726	1, 486, 773	16, 723, 302	5, 428, 113	122, 353, 936
1880	67, 307, 343	3, 678, 470	14, 505, 463	34, 162, 701	3, 922, 032	1, 777, 699	1, 336, 088	17, 801, 700	8, 760, 690	153, 252, 795

a No record by ports published for these years.

TABLE IX.—QUANTITIES OF CORN OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1862 TO 1880, INCLUSIVE.

Years.	Ports from which exported.									Total.
	New York.	Boston.	Philadelphia.	Baltimore.	New Orleans.	Chicago.	Milwaukee.	San Francisco.	All other.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1862	14, 115, 962	60, 687	777, 150	687, 401	....	1, 660, 378	....	....	1, 603, 320	[b]18, 904, 898
1863	10, 880, 962	37, 303	420, 205	482, 533	73, 604	3, 159, 945	....	....	1, 055, 864	16, 119, 476
1864	2, 642, 588	28, 701	82, 767	72, 635	50, 128	819, 926	....	....	390, 940	4, 096, 694
1865	1, 052, 407	7, 832	88, 912	127, 622	51, 892	1, 069, 093	....	....	414, 968	2, 812, 726
1866 (a)	....	....	....	....	....	....	....	....	....	....
1867 (a)	....	....	....	....	....	....	....	....	....	....
1868	7, 369, 647	25, 344	698, 587	618, 353	471, 102	1, 363, 560	....	....	600, 897	11, 147, 490
1869	3, 694, 386	18, 637	198, 283	617, 464	469, 228	986, 201	....	....	1, 122, 908	7, 047, 197
1870	401, 939	6, 607	60, 632	119, 433	128, 805	413, 116	....	....	261, 583	1, 392, 115
1871	4, 662, 238	160, 480	557, 090	1, 012, 320	508, 945	1, 620, 072	....	....	1, 304, 564	9, 826, 369
1872	18, 331, 147	1, 448, 156	2, 702, 394	4, 062, 893	790, 959	4, 050, 648	....	....	3, 105, 453	34, 491, 650
1873	20, 211, 512	947, 584	2, 909, 150	5, 860, 519	946, 457	3, 583, 451	....	....	4, 074, 257	38, 541, 930
1874	18, 096, 175	240, 775	2, 218, 802	6, 800, 600	1, 102, 597	2, 641, 294	....	....	2, 629, 354	34, 434, 606
1875	15, 107, 294	1, 074, 511	3, 546, 182	5, 577, 404	239, 512	1, 307, 441	....	....	2, 006, 076	28, 858, 420
1876	14, 741, 661	2, 721, 297	11, 286, 092	14, 803, 348	1, 417, 035	1, 971, 283	....	....	2, 553, 456	49, 493, 572
1877	19, 378, 201	3, 074, 244	13, 257, 780	21, 871, 082	2, 892, 054	3, 022, 071	....	....	6, 465, 491	70, 860, 983
1878	29, 440, 817	4, 480, 981	17, 850, 668	19, 614, 832	5, 764, 678	3, 616, 836	....	....	4, 686, 286	85, 461, 098
1879	30, 981, 052	3, 153, 028	16, 465, 858	19, 006, 017	3, 956, 801	3, 953, 509	....	....	3, 780, 487	86, 296, 252
1880	39, 489, 387	8, 412, 913	16, 016, 110	17, 494, 878	8, 039, 417	3, 958, 226	81, 600	132, 559	4, 544, 787	98, 169, 877

a No record by ports published for these years.

b A discrepancy of 11 bushels will be noticed between totals of Indian corn for 1862 as made up in tables VI, IX, and XII.

TABLE X.—QUANTITIES OF WHEAT FLOUR OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1862 TO 1880, INCLUSIVE.

Years.	Ports from which exported.									Total.
	New York.	Boston.	Philadelphia.	Baltimore.	New Orleans.	Chicago.	Milwaukee.	San Francisco.	All other.	
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1862	3, 258, 467	486, 841	521, 466	337, 201	....	20, 525	30, 359	93, 702	127, 322	4, 882, 033
1863	2, 820, 979	361, 704	380, 005	371, 690	21, 316	78, 749	40, 069	140, 989	159, 555	4, 390, 055
1864	2, 240, 262	300, 436	290, 489	338, 667	27, 649	46, 011	61, 206	168, 710	77, 917	3, 557, 347
1865	1, 620, 623	247, 423	225, 582	260, 525	19, 302	30, 662	39, 246	42, 149	119, 030	2, 604, 542
1866 (*a*)	....	....	....	....	....	....	....	....	....	....
1867 (*a*)	....	....	....	....	....	....	....	....	....	....
1868	1, 111, 448	181, 718	72, 530	247, 106	67, 695	30, 499	443	277, 042	87, 282	2, 076, 423
1869	1, 144, 476	182, 117	82, 400	240, 602	167, 363	22, 095	674	300, 510	105, 558	2, 431, 873
1870	1, 896, 004	176, 964	146, 929	350, 540	264, 337	4, 609	4, 413	340, 736	278, 801	3, 463, 333
1871	2, 041, 892	220, 027	140, 156	489, 216	163, 146	20, 654	21, 859	198, 223	358, 668	3, 653, 841
1872	1, 138, 035	155, 604	125, 642	356, 251	89, 911	2, 189	902	267, 083	378, 918	2, 514, 535
1873	1, 361, 332	171, 504	105, 743	317, 704	54, 006	6, 170	500	257, 705	287, 353	2, 562, 086
1874	2, 008, 036	208, 128	185, 540	412, 743	133, 079	24, 916	1, 381	598, 240	432, 031	4, 094, 094
1875	1, 966, 740	238, 200	171, 640	468, 233	83, 653	10, 972	640	452, 984	580, 654	3, 973, 128
1876	2, 069, 174	222, 870	171, 656	458, 337	82, 802	6, 818	....	424, 928	408, 828	3, 935, 512
1877	1, 463, 933	211, 899	140, 237	372, 921	42, 705	10, 364	....	501, 653	593, 953	3, 343, 665
1878	2, 105, 383	265, 140	150, 290	482, 021	38, 722	59	....	423, 551	392, 167	3, 947, 333
1879	3, 236, 292	451, 544	179, 056	546, 782	69, 948	5, 022	....	528, 105	612, 965	5, 629, 714
1880	3, 628, 291	681, 241	226, 559	453, 418	51, 766	1, 541	....	467, 170	501, 433	6, 011, 419

a No record by ports published for those years.

TABLE XI.—QUANTITY AND VALUE OF WHEAT FLOUR OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1860 TO 1880, INCLUSIVE.

Years.	Countries to which exported.							Total quantity.	Total value.
	Great Britain and Ireland.	British America.	British West Indies.	Brazil.	Hayti and San Domingo.	Cuba.	Other countries.		
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Dollars.*
1860	406, 847	824, 402	208, 377	502, 124	91, 682	11, 848	476, 226	2, 611, 596	15, 448, 507
1861	2, 429, 117	652, 973	*a*294, 418	364, 612	72, 044	3, 769	500, 823	4, 323, 756	24, 645, 849
1862	2, 239, 446	724, 469	*b*371, 523	373, 302	90, 375	22, 043	*c*1, 060, 875	4, 882, 033	27, 534, 677
1863	1, 794, 490	964, 544	*b*400, 087	408, 820	136, 112	32, 502	652, 504	4, 390, 055	28, 366, 069
1864	979, 754	865, 986	*b*427, 177	407, 974	128, 624	59, 568	688, 264	3, 557, 347	25, 588, 249
1865	400, 072	738, 040	*a*370, 270	306, 840	150, 604	27, 785	550, 931	2, 604, 542	27, 222, 031
1866	136, 020	823, 955	*a*260, 582	206, 144	85, 825	38, 064	542, 460	2, 183, 050	18, 396, 686
1867	116, 200	308, 551	*a*232, 571	166, 353	41, 020	10, 545	424, 767	1, 300, 106	12, 803, 775
1868	484, 706	386, 483	*a*229, 192	247, 645	61, 839	104, 418	562, 640	2, 076, 423	20, 887, 798
1869	407, 082	502, 679	331, 875	384, 134	38, 412	143, 531	624, 160	2, 431, 873	18, 813, 865
1870	1, 188, 951	532, 260	419, 456	376, 217	64, 165	149, 183	733, 101	3, 463, 333	21, 169, 593
1871	1, 227, 624	666, 842	400, 938	455, 673	67, 077	180, 027	646, 660	3, 653, 841	24, 093, 184
1872	828, 544	530, 088	421, 963	382, 216	72, 845	164, 146	614, 733	2, 514, 535	17, 955, 684
1873	531, 801	435, 435	433, 302	408, 648	110, 029	92, 532	550, 339	2, 562, 086	19, 381, 604
1874	1, 703, 084	441, 526	422, 198	531, 379	100, 248	199, 427	635, 332	4, 094, 094	29, 258, 094
1875	1, 231, 324	584, 385	*a*479, 153	590, 832	104, 467	127, 247	756, 720	3, 973, 128	23, 712, 440
1876	1, 335, 185	538, 241	*a*535, 803	536, 180	186, 273	91, 050	712, 780	3, 935, 512	24, 433, 470
1877	918, 283	640, 801	*a*429, 198	482, 200	135, 272	91, 122	646, 789	3, 343, 665	21, 663, 947
1878	1, 615, 470	423, 331	*a*445, 260	616, 132	122, 814	21, 022	703, 286	3, 947, 333	25, 095, 721
1879	2, 629, 665	504, 920	*a*361, 411	717, 377	140, 253	121, 272	1, 154, 816	5, 629, 714	29, 567, 713
1880	3, 645, 952	277, 666	333, 950	537, 914	106, 720	101, 326	1, 007, 891	6, 011, 419	35, 333, 197

a Includes Honduras and British Guiana. *b* Includes South American colonies. *c* 525,910 barrels to France.

TABLE XII.—QUANTITY AND VALUE OF CORN OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1860 TO 1880, INCLUSIVE.

Years.	Countries to which exported. Great Britain and Ireland.	British America.	France.	Belgium.	British West Indies, Honduras, and Guiana.	Cuba.	Other countries.	Total quantity.	Total value.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Dollars.*
1860	1,941,325	989,825	....	75	127,254	34,573	221,103	3,314,155	2,399,808
1861	8,127,522	1,953,544	13,707	....	200,343	112,101	270,037	10,678,244	6,890,805
1862	14,473,707	3,331,515	277,736	62,986	a212,138	b200,768	345,969	18,904,909	10,387,383
1863	10,783,707	4,383,881	73	2,588	a215,406	b171,262	502,559	16,119,476	10,592,704
1864	2,248,801	1,307,175	10	....	a214,434	b23,308	302,966	4,096,694	3,353,280
1865	763,369	1,544,370	....	....	187,750	59,802	257,345	2,812,726	3,679,133
1866	9,880,232	2,880,501	....	....	152,270	294,450	300,180	13,510,651	11,070,395
1867	12,107,064	2,288,590	....	....	161,696	27,982	214,491	14,889,823	14,871,092
1868	8,707,988	2,035,043	35,426	....	126,312	64,431	178,290	11,147,490	13,094,036
1869	4,257,591	2,168,144	54,849	....	226,266	55,009	285,248	7,047,107	6,820,719
1870	40,900	729,630	237	....	135,735	237,291	248,323	1,392,115	1,287,575
1871	5,905,445	2,070,733	77,671	11,271	233,602	205,257	332,330	9,826,309	7,458,997
1872	25,779,331	7,329,098	161,496	1,077	190,695	107,002	921,751	34,491,650	23,984,365
1873	29,334,759	7,623,255	134,933	42,074	a246,950	437,162	721,897	38,541,930	23,794,694
1874	26,299,323	5,348,938	452,951	84,798	a242,635	661,159	1,344,802	34,434,606	24,769,951
1875	23,387,367	3,202,780	346,456	137,500	a248,568	278,870	1,166,879	28,858,420	24,456,937
1876	42,452,240	4,033,062	246,620	2,500	a272,002	539,264	1,947,785	49,493,572	33,265,280
1877	55,466,435	9,038,881	1,303,281	315,308	a281,232	284,859	4,110,987	70,860,983	41,621,245
1878	65,915,851	7,633,468	2,872,784	904,614	a357,975	301,115	7,475,201	85,461,098	48,030,358
1879	64,506,811	7,297,027	2,504,226	1,341,946	a317,702	934,516	9,334,524	86,296,252	40,655,120
1880	55,635,347	7,187,203	8,573,845	2,474,934	a366,947	524,701	23,406,810	98,169,877	53,298,247

a Includes Central and South American colonies. *b* Includes all Spanish West Indies.

TABLE XIII.—QUANTITIES OF CORN MEAL OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1862 TO 1880, INCLUSIVE.

Years.	Ports from which exported. New York.	Boston.	Philadelphia.	Baltimore.	New Orleans.	Chicago.	Milwaukee.	San Francisco.	All other.	Total.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1862	135,774	21,702	46,444	23,204	....	13	....	....	26,433	253,570
1863	134,208	27,781	37,350	25,585	1,088	2,835	....	....	29,101	257,948
1864	152,815	21,643	34,859	28,448	17	266	....	....	24,309	262,357
1865	113,248	13,665	33,175	19,982	19	222	....	....	19,108	199,419
1866 (*a*)	....	....	....	....	....	....	....	....	....	....
1867 (*a*)	....	....	....	....	....	....	....	....	....	....
1868	174,510	56,012	23,181	50,455	372	5,885	....	....	26,093	336,508
1869	165,061	44,095	33,169	35,897	568	636	....	....	29,931	309,867
1870	114,868	14,346	24,074	18,039	457	342	....	....	14,067	187,093
1871	111,740	18,479	28,490	26,729	511	376	....	....	25,480	211,811
1872	151,103	56,576	33,488	42,438	345	950	....	....	24,540	308,840
1873	201,097	72,422	34,754	62,061	719	2,250	....	....	29,808	403,111
1874	201,991	85,258	28,086	44,608	572	1,372	....	....	25,920	387,807
1875	157,808	66,832	22,300	23,549	2,829	155	....	....	18,181	291,654
1876	186,252	80,326	31,299	34,551	3,073	820	....	....	17,919	354,240
1877	206,674	104,040	25,811	33,633	109	1,799	....	....	75,742	447,907
1878	205,633	85,313	29,310	23,208	623	335	....	....	88,331	432,753
1879	172,425	112,670	23,421	15,430	1,397	2,006	....	....	68,971	397,160
1880	151,772	136,491	13,038	7,216	3,557	1,395	....	107	36,437	350,013

a No record by ports published for these years.

TABLE XIV.—QUANTITIES AND VALUES OF CORN MEAL OF DOMESTIC PRODUCTION EXPORTED FROM THE UNITED STATES FROM 1860 TO 1880, INCLUSIVE.

Years.	COUNTRIES TO WHICH EXPORTED.						Total.	Total value.
	Great Britain and Ireland.	British America.	British West Indies, Honduras, and Guiana.	Cuba.	Porto Rico.	Other countries.		
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Dollars.*
1860	951	64, 469	105, 502	1, 903	16, 158	44, 720	233, 709	912, 075
1861	2, 836	56, 258	88, 770	2, 560	8, 008	44, 281	203, 313	692, 003
1862	1, 674	79, 162	*a*117, 330	*b*25, 512	*c*	29, 886	253, 570	778, 344
1863	2, 330	83, 952	*a*112, 532	*b*22, 162	*c*	36, 072	257, 048	1, 013, 272
1864	1, 081	48, 347	*a*127, 920	*b*35, 838	*c*	49, 171	262, 357	1, 349, 705
1865	459	31, 242	104, 051	3, 001	10, 084	40, 082	199, 419	1, 489, 886
1866	5, 412	75, 460	84, 947	3, 028	18, 060	48, 868	237, 275	1, 129, 484
1867	2, 180	100, 388	105, 220	5, 633	13, 441	48, 413	284, 281	1, 555, 585
1868	1, 062	154, 939	90, 715	1, 310	29, 837	58, 636	336, 508	2, 008, 430
1869	4, 304	126, 218	115, 586	3, 130	20, 596	40, 033	309, 867	1, 656, 273
1870	6, 363	39, 749	86, 785	1, 031	11, 854	41, 311	187, 093	935, 076
1871	1, 220	69, 287	96, 356	1, 757	10, 160	33, 031	211, 811	951, 830
1872	1, 757	146, 121	108, 529	5, 230	11, 916	35, 278	308, 840	1, 214, 099
1873	935	197, 070	*a*141, 021	2, 374	15, 863	45, 848	403, 111	1, 474, 827
1874	1, 757	183, 328	*a*131, 512	2, 061	10, 678	58, 471	387, 807	1, 529, 399
1875	4, 016	129, 124	*a*104, 917	11, 030	3, 834	38, 733	291, 654	1, 290, 533
1876	279	154, 907	*a*139, 736	5, 186	9, 823	44, 809	354, 240	1, 305, 027
1877	9, 492	271, 820	*a*101, 359	1, 905	12, 468	50, 863	447, 907	1, 511, 152
1878	7, 088	232, 047	*a*130, 398	840	4, 000	57, 480	432, 753	1, 336, 187
1879	4, 808	211, 927	118, 637	5, 227	3, 588	52, 973	397, 160	1, 052, 231
1880	17, 434	169, 131	108, 808	3, 174	9, 205	42, 739	*d*350, 041	981, 361

a Includes Central and South American colonies.
b Includes all Spanish West Indies.
c Included in Cuba.
d A discrepancy of 28 barrels will be noticed between the totals for 1880, as made up in tables XIII and XIV

Commerce in agricultural products in general, and food products in particular, is as old as civilization; but its present methods are very new, and its rapid increase is profoundly affecting all those countries with which we are most intimately related by ties of blood or of commerce.

The first aim of the agriculture of any country is the production of the materials required to feed and clothe the people of that country. This done, then to produce such luxuries as can be grown, and also the raw materials used in manufactures, and lastly to produce a surplus to export. The export of a surplus, however, often precedes its manufacture. The present generation, by the introduction of steam transportation, by new inventions and appliances for putting in crops and harvesting them, by the applications of science in increasing the yield and in suggesting new uses to which the cereals may be applied, has introduced entirely new problems into this industry and into other productive industries. The daily bread of all civilized countries is so immediately dependent on agricultural production that these new conditions of both production and transportation have modified the problems of political and social economy in all christendom, and matters which once had but a local interest have suddenly become of world-wide importance. As a consequence, our agricultural productions and our agricultural methods, with the facts pertaining to them, have in one way or another become important factors of disturbance in the political and social economy of every country of Europe, showing themselves in a variety of ways: here by the reduction of the rents, there by the decrease of the value of agricultural lands, or by the increase of the use of improved agricultural implements and machines, by the decrease of prices of home-grown productions, by changes in courses of cropping, by modifications in landholdings, by distress among farmers, by emigration, by political uneasiness, and so on through a long list of effects, some immediately and others more remotely related to American agricultural competition. The disturbance has been particularly great where the systems of landholding are most affected by the laws, customs, and traditions which have remained from a previous age. In some countries so great has been the effect that numerous observers consider the present period economically, and in a sense politically, a "crisis", hastened, if not actually caused, by that development of American agriculture which relates to food production.

These facts, taken in connection with the magnitude of our grain and food exports, make it important that, along with the bald tables of grain production, the methods and conditions of that production be discussed. I shall therefore consider, first, the distribution of our cereal production according to several factors; next, certain facts pertaining to the cereals as a whole; then the special crops in detail; and finally, a further consideration of some of the facts and conditions pertaining to our cereal production.

Cereal production in the United States has attained its present importance and assumed its present features under the molding influences of a great number and variety of conditions. The fact is simple, but the causes are complicated, and unlike factors are so correlated that very different conclusions may be reached, according as we give greater or less importance to this or that factor in the complex problem. It is therefore important that so many of the factors as are practicable be considered separately.

The distribution of grain production in the United States may be considered in respect to three classes of conditions: First, the distribution according to geographical features, such as by states, by latitude and longitude, according to topographical features or physical characters, by drainage basins, and by hypsometric groups (elevation above the sea); second, according to geological features and soil; and third, according to climatic conditions, such as temperature, rainfall, storms, or special climatic peculiarities. Then beyond these are many factors which are largely social, belonging to race, to custom, to questions of land, some of which will be considered later.

DISTRIBUTION BY STATES.

While the cereals are grown in every state and territory of the Union, and in nearly every county, yet the great bulk of the production is in a belt belonging to what are popularly called the northern states, if this be made to include Missouri, Kansas, and Nebraska. But even in this belt the amount is very unequally distributed. The aggregate grown by each of the several states and territories in the order of their production is seen in the following table, along with percentages of total production and other data.

TABLE XV.—TOTAL CEREAL PRODUCTION BY STATES, AND PER CENT. OF TOTAL PRODUCED BY EACH.

	States.	Total production.	Per cent. of total.	Cumulative per cent.		States.	Total production.	Per cent. of total.	Cumulative per cent.
		Bushels.					*Bushels.*		
	Total	2,697,962,456	100.00	....	26	South Carolina	15,488,208	0.57	97.23
					27	Oregon	12,933,019	0.48	97.71
1	Illinois	444,622,350	16.48	16.48	28	Louisiana	10,142,076	0.38	98.09
2	Iowa	362,497,131	13.44	29.92	29	Dakota	7,352,589	0.27	98.36
3	Missouri	248,839,405	9.22	39.14	30	Vermont	6,789,786	0.25	98.61
4	Ohio	188,933,077	7.00	46.14					
5	Indiana	179,142,318	6.64	52.78	31	Delaware	5,400,877	0.20	98.81
6	Kansas	131,971,726	4.89	57.67	32	Maine	4,543,206	0.17	98.98
7	Pennsylvania	106,840,422	3.96	61.63	33	Washington	4,108,370	0.15	99.13
8	Wisconsin	99,661,326	3.69	65.32	34	Florida	3,645,943	0.14	99.27
9	Kentucky	89,953,432	3.34	68.66	35	Connecticut	3,449,451	0.13	99.40
10	New York	89,926,704	3.33	71.99					
11	Michigan	88,097,084	3.27	75.26	36	Massachusetts	2,810,481	0.10	99.50
12	Nebraska	88,039,613	3.26	78.52	37	New Hampshire	2,743,759	0.10	99.60
13	Minnesota	76,044,895	2.82	81.34	38	Colorado	2,648,573	0.10	99.70
14	Tennessee	75,037,844	2.78	84.12	39	Utah	1,977,368	0.07	99.77
15	California	45,135,852	1.67	85.79	40	New Mexico	1,547,247	0.06	99.83
16	Virginia	42,737,994	1.58	87.37	41	Montana	1,417,089	0.05	99.88
17	Texas	36,625,011	1.36	88.73	42	Idaho	1,298,324	0.05	99.93
18	North Carolina	35,587,549	1.32	90.05	43	Nevada	782,519	0.03	99.96
19	Georgia	32,031,312	1.19	91.24	44	Rhode Island	564,580	0.02	99.98
20	Alabama	30,054,620	1.11	92.35	45	Arizona	410,788	0.02	100.00
21	Arkansas	27,670,856	1.03	93.38					
22	Maryland	26,199,100	0.97	94.35	46	District of Columbia	47,296	0.00	0.00
23	Mississippi	23,524,702	0.87	95.22	47	Wyoming	27,264	0.00	0.00
24	West Virginia	20,409,044	0.76	95.98					
25	New Jersey	18,182,586	0.68	96.66					

The above table of aggregates merely shows the relative importance of the states as compared with each other, and not the actual importance of grain production to the individual states themselves. This last question is related in part to the average production per head of population, and in part to the relative amount of improved land in grain. These factors will be better seen in the maps and in the other tables.

Illinois is the leading state in each of the three most abundant cereals, maize, wheat, and oats, its products amounting to 16.48 per cent. of the total grain product of the country. The crop of five contiguous states Ohio, Indiana, Illinois, Missouri, and Iowa, amounts to 52.78 per cent. of all our grain. The quantities of each cereal produced by the states, respectively, will be found in the special tables under the respective grains. It will be noticed also that the most of the grain of the United States is grown in regions where mixed farming is practiced, and on farms of moderate size. By mixed farming I mean the growing of both green and grain crops, and the production of animals on the same farm. In special cases some one crop, particularly wheat, is cultivated to the exclusion of others, and some of these cases, from their magnitude, or their unusual methods, or their pecuniary success, or their romantic history, have been so prominently before the public that their relative importance in respect to the whole grain product is much overrated in the popular imagination.

DISTRIBUTION OF THE CEREAL PRODUCTION IN ACCORDANCE WITH GEOGRAPHICAL, PHYSICAL, AND CLIMATIC FEATURES.

The tables of grain distribution according to physical moments, prepared under the direction of Mr. Gannett, form a new and most important feature in the statistics of grain production, and constitute a scientific investigation of especial economic interest, introducing new scientific data to aid in the solution of future problems. Grain-growing has reached its present magnitude only by the aid of physical science. The tables giving the distribution by latitude and longitude, by topographical divisions, and by drainage-basins are so plain that they need little comment.

The tables, which show the distribution according to the various physical features of the country as a whole, will be found in the text which follows.

The tables have been prepared by using the production of each county as a unit, the counties lying within different divisions being taken off from maps upon which these lines had been sketched. It is to be understood, of course, that the distribution is not, and cannot be from the nature of things, an exact one, inasmuch as lines of different temperatures, amount of rainfall, elevation above sea-level, etc., cannot be drawn with any great degree of certainty, and because, in cases where parts of counties lie in different divisions, the division of the county cannot be made with exactness.

The tables of distribution by latitude and longitude show that the most of the crop is produced between 38° and 45° of latitude, the different grains, of course, having the center of their belt not quite coincident, but the three degrees between 40° and 43° may be considered as the center of the belt.

DISTRIBUTION IN ACCORDANCE WITH TOPOGRAPHICAL FEATURES.

The tables of distribution by topographical features show that the "prairie region" produces 37.7 per cent., or about three-eighths of the whole, the "central region" following: these two producing nearly as much as all the other nineteen topographical divisions into which the country is divided for this investigation.

TABLE XVI.—THE DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE TOPOGRAPHICAL FEATURES OF THE COUNTRY.

Topographical regions.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
North Atlantic coast	348, 150	217, 108	1, 582, 405	266, 068	8, 234, 550	81, 754
Middle Atlantic coast	8, 800, 477	14, 520	3, 935, 820	860, 257	30, 101, 352	195, 057
South Atlantic coast	257, 500	000	1, 030, 000	32, 300	10, 522, 100	....
Gulf coast	2, 022	210	580, 712	2, 965	9, 096, 634	....
Northeastern Appalachian region	1, 207, 887	774, 616	10, 703, 816	594, 847	6, 308, 074	1, 873, 789
Central Appalachian region	13, 158, 405	186, 601	20, 780, 373	2, 777, 031	33, 290, 300	3, 680, 707
Region of the great lakes	22, 086, 943	4, 053, 231	28, 115, 100	964, 618	32, 204, 434	626, 300
Interior plateau	20, 720, 559	4, 761, 821	46, 664, 913	3, 080, 911	62, 005, 854	4, 040, 600
Southern Appalachian region	13, 343, 272	31, 656	9, 713, 319	822, 809	73, 573, 405	421, 891
Ohio valley	23, 424, 300	1, 492, 729	8, 223, 200	333, 600	81, 184, 917	149, 586
Southern interior plateau	4, 242, 919	35, 305	10, 764, 164	85, 183	66, 650, 805	1, 863
Mississippi river belt, south	857, 000	....	412, 700	7, 800	16, 123, 200	....
Mississippi river belt, north	43, 983, 600	3, 268, 900	30, 834, 000	1, 107, 800	119, 130, 350	100, 400
Southwest central region	10, 705, 224	55, 738	12, 275, 321	95, 409	108, 300, 285	9, 283
Central region	79, 890, 788	922, 761	36, 505, 561	932, 176	230, 162, 204	230, 207
Prairie region	125, 501, 556	10, 260, 906	140, 510, 119	6, 173, 330	720, 635, 825	593, 940
Missouri river belt	13, 528, 034	779, 902	9, 226, 800	344, 120	110, 717, 707	19, 021
Western plains	2, 707, 000	145, 816	844, 400	70, 405	5, 078, 068	1, 200
Heavily timbered region of the Northwest	32, 516, 400	1, 959, 516	16, 445, 103	440, 700	25, 553, 414	251, 162
Cordilleran region	27, 442, 059	8, 483, 509	4, 254, 396	179, 404	1, 554, 405	14, 852
Pacific coast	14, 745, 510	6, 961, 600	5, 488, 627	44, 700	1, 404, 887	16, 715
Total	459, 479, 505	44, 113, 495	407, 858, 999	19, 831, 595	1, 754, 861, 535	11, 817, 327

Considered by drainage-basins, the great Mississippi basin, of course, leads all the rest, as will be seen in a discussion of the special crops.

TABLE XVII.—DISTRIBUTION OF CEREAL PRODUCTION BY DRAINAGE-BASINS.

Drainage-basins.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
ATLANTIC OCEAN	410, 177, 000	28, 777, 700	399, 139, 200	19, 606, 200	1, 752, 348, 800	11, 784, 300
New England coast	1, 005, 600	500, 600	6, 195, 300	658, 900	6, 847, 800	833, 300
St. John's river	131, 900	18, 600	602, 700	1, 000	12, 600	268, 900
Penobscot river	182, 600	48, 200	554, 200	4, 300	131, 000	65, 100
Kennebec river	202, 400	97, 200	877, 700	7, 800	401, 000	47, 400
Merrimac river	76, 200	44, 900	409, 500	30, 800	911, 600	25, 300
Connecticut river	195, 900	134, 600	2, 064, 600	278, 300	2, 516, 200	274, 900
Housatonic river	9, 700	10, 400	461, 000	102, 200	476, 900	52, 800
Middle Atlantic coast	31, 491, 700	932, 500	44, 079, 900	6, 607, 300	82, 969, 400	6, 091, 900
Hudson river	575, 600	233, 100	9, 404, 400	1, 836, 500	6, 512, 300	1, 650, 400
Delaware river	4, 609, 300	18, 800	8, 974, 300	2, 130, 400	16, 566, 200	1, 022, 900
Susquehanna river	10, 983, 900	650, 200	19, 501, 800	1, 429, 500	24, 530, 400	2, 917, 000
Potomac river	9, 410, 500	17, 200	2, 130, 200	432, 400	16, 061, 500	236, 100
South Atlantic coast	9, 044, 100	36, 500	12, 396, 100	259, 700	63, 329, 200	47, 300
James river	1, 518, 400	4, 200	1, 344, 400	29, 000	5, 437, 400	24, 900
Cape Fear river	522, 800	1, 400	487, 900	17, 800	3, 798, 500	....
Neuse river	329, 700	....	323, 800	12, 900	3, 574, 200	....
Pedee river	1, 090, 100	1, 600	1, 628, 500	56, 400	8, 697, 400	2, 300
Roanoke river	1, 267, 700	....	1, 952, 300	31, 800	6, 666, 700	10, 800
Santee river	1, 141, 300	10, 400	1, 709, 000	28, 700	8, 092, 800	....
Savannah river	641, 900	8, 600	1, 472, 800	17, 600	4, 007, 800	....
Altamaha river	792, 000	8, 500	1, 209, 000	21, 000	5, 777, 700	....
Great lakes	78, 466, 700	10, 576, 800	67, 040, 400	2, 082, 900	99, 337, 400	2, 247, 100
St. Lawrence river	565, 400	517, 300	5, 689, 700	230, 400	2, 259, 600	521, 800
Lake Ontario	8, 213, 400	6, 058, 400	13, 661, 800	227, 000	12, 274, 600	935, 500
Lake Erie	22, 336, 500	1, 160, 000	18, 826, 600	224, 100	38, 430, 900	330, 000
Lake Huron	9, 755, 500	696, 100	7, 404, 300	85, 200	7, 981, 700	147, 900
Lake Michigan	33, 783, 500	2, 000, 700	20, 340, 600	1, 297, 900	38, 299, 300	308, 500
Lake Superior	18, 200	5, 400	50, 700	4, 800	2, 200	....
Red River of the North	3, 794, 200	138, 900	1, 066, 700	13, 500	89, 100	2, 500
Gulf of Mexico	259, 108, 900	16, 731, 300	268, 827, 500	9, 097, 400	1, 499, 865, 000	2, 564, 700
Peninsula of Florida	....	....	256, 800	2, 500	1, 830, 100	....
Apalachicola river	870, 300	4, 900	1, 729, 700	26, 800	7, 301, 500	....
Mobile river	2, 074, 800	7, 200	3, 052, 800	34, 100	25, 288, 000	2, 500
Tombigbee river	340, 900	2, 400	1, 070, 600	8, 600	11, 389, 600	....
Alabama river	1, 733, 900	4, 800	1, 981, 500	25, 500	13, 891, 500	1, 400
Pascagoula river	1, 400	....	342, 700	....	1, 371, 600	....
Pearl river	14, 300	....	489, 300	....	2, 771, 900	....
Sabine river	65, 600	1, 200	576, 800	3, 400	4, 374, 100	....
Trinity river	1, 108, 300	35, 100	1, 542, 900	6, 000	6, 733, 700	2, 600
Brazos river	834, 000	12, 300	1, 334, 500	7, 100	6, 697, 800	....
Colorado River of Texas	159, 700	6, 000	251, 200	3, 700	2, 280, 200	....
Nueces river	4, 100	....	11, 700	....	92, 500	....
San Antonio river	78, 100	1, 100	146, 400	2, 500	1, 155, 500	....
Rio Grande	506, 400	42, 600	152, 900	....	697, 800	4, 000
Mississippi river	293, 425, 700	16, 646, 000	257, 541, 200	9, 022, 700	1, 446, 880, 400	2, 555, 000
Yazoo river	91, 200	....	330, 100	2, 200	7, 693, 700	200
Illinois river	18, 656, 000	386, 500	34, 350, 900	1, 858, 700	184, 816, 200	91, 900
Rock river	6, 709, 200	2, 962, 600	20, 078, 600	1, 207, 100	46, 339, 100	97, 800
Wisconsin river	3, 359, 100	452, 600	5, 633, 100	486, 900	7, 035, 500	97, 800
Chippewa river	2, 291, 500	107, 100	2, 251, 200	53, 900	1, 081, 100	13, 100
St. Croix river	2, 099, 300	117, 300	1, 180, 200	16, 500	487, 000	2, 300
Minnesota river	9, 236, 800	582, 700	7, 096, 100	43, 600	4, 948, 000	9, 200
Cedar river	12, 009, 800	1, 297, 700	14, 888, 500	365, 600	63, 653, 900	48, 200
Des Moines river	5, 733, 900	357, 100	9, 611, 600	307, 800	56, 486, 100	23, 600
Ohio river	107, 058, 100	2, 505, 200	59, 865, 200	2, 456, 700	394, 046, 400	1, 876, 700
Tennessee river	5, 728, 700	23, 300	4, 585, 900	263, 600	46, 175, 300	73, 300
Cumberland river	3, 297, 600	10, 800	1, 725, 600	91, 900	27, 383, 000	3, 500
Kentucky river	2, 167, 200	347, 900	517, 300	203, 200	12, 003, 800	3, 500
Green river (of Kentucky)	1, 904, 300	4, 000	1, 536, 400	74, 100	15, 948, 000	1, 000
Licking river	2, 052, 400	48, 500	433, 100	126, 500	9, 366, 600	2, 700
Kanawha river	1, 124, 800	....	1, 107, 800	180, 600	5, 338, 000	113, 800
Monongahela river	2, 225, 400	28, 800	2, 905, 300	110, 900	6, 760, 400	240, 300
Allegheny river	1, 847, 100	143, 200	7, 736, 300	407, 000	6, 208, 000	828, 900
Miami river	6, 919, 300	948, 900	2, 876, 600	36, 700	17, 459, 200	17, 800
Scioto river	6, 239, 400	46, 500	1, 886, 700	36, 700	25, 706, 300	26, 200
Muskingum river	8, 923, 900	54, 100	6, 793, 900	53, 000	15, 218, 000	66, 000
Wabash river	43, 678, 800	191, 300	14, 710, 100	207, 000	129, 620, 000	78, 300
Big Sandy river	281, 000	....	259, 500	22, 700	3, 656, 000	4, 800

TABLE XVII.—DISTRIBUTION OF CEREAL PRODUCTION BY DRAINAGE-BASINS—Continued.

Drainage-basins.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
ATLANTIC OCEAN—Continued.						
Gulf of Mexico—Continued.						
Mississippi river—Continued.						
Missouri river	48, 930, 500	3, 103, 900	85, 803, 500	1, 521, 000	349, 051, 500	80, 800
Big Sioux river	1, 130, 000	206, 400	1, 586, 800	38, 700	2, 343, 800	4, 400
Yellowstone river	31, 700	1, 800	64, 400	...	...	...
Platte river	6, 142, 800	466, 100	3, 190, 400	101, 300	22, 122, 100	5, 100
Kansas river	15, 190, 800	1, 138, 700	5, 459, 400	440, 800	63, 018, 400	18, 600
Osage river	2, 837, 300	...	2, 550, 700	15, 600	30, 771, 100	2, 900
Arkansas river	11, 007, 900	52, 700	7, 045, 300	112, 300	82, 055, 100	21, 100
Cimarron river	12, 600	...	2, 900	...	6, 300	...
Canadian river	141, 500	6, 700	53, 100	...	130, 500	...
White river	2, 984, 600	1, 300	2, 343, 100	20, 100	21, 905, 300	3, 600
Red river of Louisiana	380, 200	6, 000	1, 447, 000	7, 400	13, 937, 500	2, 800
Washita river	84, 600	...	278, 400	3, 500	4, 824, 500	...
St. Francis river	499, 200	3, 700	372, 700	3, 400	4, 431, 200	...
GREAT BASIN	1, 338, 200	876, 900	675, 900	13, 000	220, 100	...
Great Salt Lake	1, 124, 500	206, 300	424, 400	10, 000	149, 900	...
Humboldt river	47, 700	292, 000	136, 200	...	2, 700	...
PACIFIC OCEAN	38, 904, 300	14, 458, 800	8, 043, 800	212, 300	2, 202, 600	33, 000
Colorado River of the West	313, 200	272, 400	82, 100	...	112, 700	1, 200
Green river	50, 200	2, 000	40, 400	...	1, 900	...
Grand river	1, 700	...	8, 500	...	...	...
Colorado Chiquito river	7, 800	9, 900	...	...	7, 000	...
Gila river	202, 800	234, 000	1, 600	...	86, 700	1, 200
Sacramento river	20, 858, 000	5, 904, 000	303, 100	143, 100	504, 700	12, 100
San Joaquin river	6, 199, 300	1, 604, 400	9, 000	110, 200	224, 800	...
Klamath river	139, 300	150, 000	220, 000	1, 800	10, 000	...
Columbia river	8, 779, 100	1, 554, 400	5, 108, 400	26, 300	97, 200	8, 200
Willamette river	5, 130, 200	155, 400	3, 050, 000	3, 300	25, 200	5, 800
Snake river	1, 432, 800	606, 500	1, 145, 600	10, 000	32, 500	1, 700
Clark's fork	187, 100	25, 600	356, 800	1, 800	7, 000	...

NOTE.—In the above table the figures are given only to even hundreds of bushels.

DISTRIBUTION ACCORDING TO ELEVATION.

The tables of distribution according to elevation show that each of the grains has its largest production at an elevation of between 500 and 1,000 feet above the sea, where 52.9 per cent. of the whole product is grown. Not only is the total product greatest, but the proportion of each grain is also greatest. The next highest proportion of each grain is between 1,000 and 1,500 feet elevation, where 27.5 per cent. of the total is produced. The next rank reached also by each of the six grains is between 100 and 500 feet, where 11.3 per cent. is found. Thus 91.7 per cent. of the grain of the country is grown between the elevation of 100 and 1,500 feet.

TABLE XVIII.—DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE ELEVATION ABOVE SEA-LEVEL.

Groups.	Wheat.	Groups.	Barley.	Groups.	Oats.	Groups.	Rye.	Groups.	Indian corn.	Groups.	Buckwheat.
	Bushels.		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*
Total	459, 470, 505	Total	44, 113, 495	Total	407, 858, 999	Total	19, 831, 595	Total	1, 754, 861, 535	Total	11, 817, 327
0 to 100	19, 537, 371	0 to 100	5, 071, 706	0 to 100	8, 391, 819	0 to 100	1, 683, 248	0 to 100	46, 923, 808	0 to 100	651, 013
100 to 500	53, 211, 080	100 to 500	8, 711, 758	100 to 500	47, 554, 528	100 to 500	3, 408, 183	100 to 500	190, 856, 357	100 to 500	1, 938, 854
500 to 1,000	239, 999, 748	500 to 1,000	14, 714, 484	500 to 1,000	210, 227, 750	500 to 1,000	8, 744, 391	500 to 1,000	949, 623, 825	500 to 1,000	3, 531, 152
1,000 to 1,500	118, 059, 847	1,000 to 1,500	10, 838, 345	1,000 to 1,500	115, 860, 400	1,000 to 1,500	4, 374, 196	1,000 to 1,500	480, 075, 520	1,000 to 1,500	3, 466, 104
1,500 to 2,000	17, 896, 207	1,500 to 2,000	1, 848, 942	1,500 to 2,000	18, 488, 200	1,500 to 2,000	1, 066, 278	1,500 to 2,000	63, 339, 845	1,500 to 2,000	1, 783, 759
2,000 to 3,000	6, 150, 038	2,000 to 3,000	1, 676, 250	2,000 to 3,000	4, 165, 836	2,000 to 3,000	855, 021	2,000 to 3,000	11, 850, 037	Above 2,000	446, 445
3,000 to 4,000	491, 700	3,000 to 4,000	61, 000	3,000 to 4,000	698, 500	Above 3,000	140, 278	3,000 to 4,000	1, 869, 808	Above 3,000	(a)
4,000 to 5,000	1, 453, 815	4,000 to 5,000	649, 347	4,000 to 5,000	1, 185, 767	Above 4,000	(a)	4,000 to 5,000	293, 649		
5,000 to 6,000	2, 264, 525	5,000 to 6,000	473, 263	5,000 to 6,000	971, 227			5,000 to 6,000	799, 599		
Above 6,000	414, 274	Above 6.000	68, 400	Above 6,000	305, 976			Above 6,000	238, 000		
Above 7,000	(a)	Above 7,000	(a)	Above 7,000	(a)			Above 7,000	(a)		

a Insignificant.

DISTRIBUTION ACCORDING TO CLIMATIC CONDITIONS.

Each species of plant, whether cultivated or growing in a state of nature, is confined within its range by certain climatic limits, beyond which it will not grow in the open air. But with cultivated plants the limits of profitable cultivation are much narrower than the limits of extreme range. We can imagine for each species an ideal climate which would be the very best as to heat, sunshine, distribution of rainfall, dryness, and winds; but each of these conditions named may exist along with other unfavorable conditions, so that the ideal climate is rarely, if ever, found. Climatic influences are the controlling conditions of grain-growing the world over, and grain countries and grain regions are made so by the climate, and not by the soil. The difference between a desert and a fertile region is often simply one of rainfall, and barren indeed must be that soil which will not produce grain enough for the wants of a very considerable population if the climate is propitious. Most varieties of cereals are the result of the molding influences produced by cultivation, adapting the plant to special climatic conditions; and the great experiment now going on along the whole western border of our central grain region, between it and the great plains, is one to ascertain where are the limits of profitable cultivation, in a region specially liable to long droughts. It is hardly proper, however, to say that rainfall is more important than temperature. It is essential that both be within certain limits. While rain, or at least water, is an absolute necessity, so also is a certain climate as regards temperature.

The production of bread-grains belongs chiefly to the temperate climates; to the belt where, owing to the winter's cold, comforts are secured only by labor. The barren season must be provided for, because neither comfort nor food can be secured except by forethought and labor in summer, and this incites to those habits of industry, prudence, and thrift which are the basis of our civilization. Although the grains grow only during the warm weather, their production is chiefly in a climate of cold winters, much of it where the winters are very cold.

The tables of distribution according to the mean temperature of January (average mid-winter temperature) show that a little less than 70 per cent. of the whole grain production of the United States is in regions where that is below 30°, and perhaps nearly three-fourths where the average for that month is below the freezing point. This is correlated with other facts, for under these same temperatures would be found most of the wealth of the country.

The tables of distribution according to annual temperatures show that 32.9 per cent. is produced where this is between 45 and 50 degrees; 72.5 per cent. where it is between 45 and 55 degrees; 84.3 per cent. where it is between 45 and 60 degrees; and 91.4 per cent. where it is between 40 and 60 degrees.

TABLE XIX.—DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE MEAN ANNUAL TEMPERATURE.

Groups.	Wheat.	Groups.	Barley.	Groups.	Oats.	Groups.	Rye.	Groups.	Indian corn.	Groups.	Buckwheat.
	Bushels.		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*
Total	459, 479, 505	Total	44, 113, 495	Total	407, 858, 999	Total	19, 831, 595	Total	1, 754, 861, 535	Total.....	11, 817, 327
Below 40°....	3, 893, 580	Below 40°...	193, 856	Below 40°...	2, 884, 810	Below 40°...	(a)	Below 40°...	449, 000	Below 40° ...	234, 800
40° to 45°	59, 828, 787	40° to 45° ...	6, 700, 282	40° to 45° ...	60, 150, 713	Below 45°...	2, 116, 604	40° to 45° ...	61, 316, 607	40° to 45°....	2, 581, 380
45° to 50°	118, 288, 822	45° to 50° ...	18, 428, 338	45° to 50° ...	190, 619, 382	45° to 50° ...	10, 090, 850	45° to 50° ...	543, 259, 832	45° to 50°...	7, 085, 028
50° to 55°	185, 176, 849	50° to 55° ...	5, 094, 018	50° to 55° ...	110, 841, 269	50° to 55° ...	6, 451, 508	50° to 55° ...	759, 032, 384	50° to 55°....	1, 832, 130
55° to 60°	58, 717, 130	55° to 60° ...	4, 535, 797	55° to 60° ...	23, 556, 021	55° to 60° ...	852, 415	55° to 60° ..	228, 545, 675	Above 55°...	83, 983
60° to 65°	31, 157, 699	60° to 65° ...	7, 714, 194	60° to 65° ...	12, 396, 083	Above 60° ..	320, 128	60° to 65° ...	112, 785, 854	Above 60°...	(a)
65° to 70°	2, 280, 202	65° to 70° ...	384, 800	65° to 70° ...	7, 109, 271	Above 65° ..	(a)	65° to 70° ...	45, 484, 549		
Above 70° ...	136, 427	Above 70° ..	162, 210	Above 70° ..	210, 000			Above 70° ..	3, 087, 534		

a Insignificant.

TABLE XX.—DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE MEAN TEMPERATURE OF JULY.

Groups.	Wheat.	Groups.	Barley.	Groups.	Oats.	Groups.	Rye.	Groups.	Indian corn.	Groups.	Buckwheat.
	Bushels.		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*		*Bushels.*
Total	459, 479, 505	Total	44, 113, 495	Total	407, 858, 900	Total	19, 831, 595	Total	1, 754, 861, 535	Total.....	11, 817, 327
Below 60°....	(a)	Below 60°...	(a)	Below 60°...	(a)	60° to 65° ...	109, 441	Below 60°...	(a)	60° to 65°....	501, 401
Below 65°....	9, 465, 900	Below 65°...	4, 539, 800	Below 65°...	8, 418, 900	65° to 70° ...	1, 912, 893	Below 65°...	4, 948, 400	65° to 70°....	4, 989, 531
65° to 70°	26, 181, 134	65° to 70° ...	9, 765, 092	65° to 70° ...	48, 517, 490	70° to 75° ...	11, 816, 645	65° to 70° ...	28, 646, 370	70° to 75°....	5, 592, 014
70° to 75°	223, 852, 371	70° to 75° ...	18, 508, 412	70° to 75° ...	218, 143, 107	75° to 80° ...	5, 786, 618	70° to 75° ...	577, 094, 509	Above 75°...	733, 481
75° to 80°	178, 530, 037	75° to 80° ...	9, 644, 976	75° to 80° ...	112, 810, 167	Above 80° ..	205, 998	75° to 80° ...	961, 123, 938	Above 80°...	(a)
80° to 85°	18, 390, 836	80° to 85° ...	553, 264	Above 80° ..	19, 960, 335	Above 85° ..	(a)	80° to 85° ...	182, 857, 018		
85° to 90°	2, 906, 466	85° to 90° ...	891, 200	Above 85° ..	(a)			Above 85° ..	191, 300		
Above 90° ...	143, 761	Above 90° ..	210, 751					Above 90° ..	(a)		

a Insignificant.

TABLE XXI.—DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE MEAN TEMPERATURE OF JANUARY.

Groups.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Total	459, 479, 505	44, 113, 495	407, 858, 999	19, 831, 595	1, 754, 861, 535	11, 817, 327
Below 5°	2, 549, 845	83, 846	1, 049, 533	2, 400	29, 800	1, 300
5° to 10°	10, 520, 600	450, 746	6, 960, 133	101, 626	2, 681, 600	12, 900
10° to 15°	48, 340, 993	5, 004, 497	46, 252, 314	982, 976	89, 456, 400	764, 278
15° to 20°	41, 205, 543	9, 086, 029	78, 247, 800	3, 851, 020	276, 697, 881	1, 107, 234
20° to 25°	107, 427, 749	11, 252, 430	128, 138, 370	6, 412, 369	455, 917, 207	6, 408, 084
25° to 30°	106, 663, 368	2, 462, 171	69, 445, 611	4, 368, 861	358, 412, 256	2, 811, 535
30° to 35°	73, 907, 989	2, 721, 475	34, 581, 365	3, 017, 085	244, 927, 879	548, 372
35° to 40°	29, 667, 192	568, 039	21, 705, 604	735, 619	185, 735, 287	133, 819
40° to 45°	10, 918, 676	1, 080, 454	10, 997, 719	118, 323	72, 013, 212	8, 170
45° to 50°	19, 646, 598	5, 167, 047	8, 120, 959	179, 342	49, 168, 524	12, 335
50° to 55°	8, 201, 852	5, 273, 761	2, 158, 491	59, 765	17, 700, 993	9, 300
55° to 60°	429, 100	957, 000	109, 700	2, 200	2, 546, 362	....
Above 60°	....	....	1, 400	....	174, 634	....

The distribution according to annual rainfall shows that 30.2 per cent. is produced where this is between 40 and 45 inches; 60.9 per cent. where it is between 35 and 45 inches; 85.2 per cent. where it is between 30 and 50 inches; and 94.4 per cent. where it is between 25 and 55 inches.

But the annual mean includes the climate of the winter as well as that of the summer, while the whole possibilities of grain-growing depend upon the climate of the growing season, during which time there must be both suitable temperature and rainfall. Irrigation may secure crops on comparatively limited areas, but for the great grain-fields of the world sufficient rain must fall on the fields themselves to admit of the growth of the crops. This must come at suitable times, and be neither too much nor too little. There must be sufficient heat at the right times for the growth of the crop, with sunshine to ripen the grain and fair weather for harvesting. Now these conditions exist in an eminent degree in the grain-growing regions of this country: a summer temperature fitted for the crops, a sunny climate suited to produce grain of a superior quality, in average years fair weather for harvesting, and that disposition of rain and sunshine to insure, in average years, abundant harvests as a whole.

The tables of distribution according to climatic influences show that on each side of the proper conditions of temperature and rainfall during the growing season the production fades out quite rapidly. The tables of distribution according to mean July temperature (average mid-summer temperature) show that 47 per cent. is produced where this is between 75° and 80°, and 86.1 per cent. where it is between 70° and 80°. A considerable proportion of that which is produced where the July temperature is higher grows where the crops ripen before or by the first week of that month, and are therefore not affected materially by the July temperature.

Considered according to the rainfall of spring and summer, or the six growing months, the tables show that 61.6 per cent. is produced where this is between 20 and 25 inches, and 97.2 per cent. where it is between 15 and 30 inches.

Regarding the absolute amount of rain necessary for the production of any crop, no empirical rule can be given. In any grain-growing region the most of the water which falls upon the soil during the growing season is removed by evaporation, but there is a great difference in soils and in regions as to the rate at which this evaporation goes on. The dryness of the air, the character of the winds, the temperature, and a variety of other conditions, determine this. The methods of cultivation also have much to do with it, for it has been demonstrated by scientific experiment that the evaporation is less from well-tilled soils than from those which are hard and poorly tilled; the common experience of farmers is that well-tilled crops stand a drought better than those not so well tilled. But the figures given in the following tables show that comparatively little grain is grown where the rainfall of the growing season is less than 15 inches, amounting to only about 2 per cent., and that is mostly wheat.

There are considerable portions of the United States where wheat may be grown very profitably in some years, but where there are failures in others because of droughts, and where it has not yet been demonstrated that this grain can be grown with profit through an average of a large number of years. It must also be remembered that in this country we are less liable to the dangers of too much wet near times of harvest, causing rust and mildew, and interfering with the gathering of the ripened grain, than in the Old World, but that these advantages of our dry, fair weather for harvest, and the clearness of our sunshine, which gives our grain its bright color and excellent physical character, bring with it dangers of excessive drought, while in districts with barely sufficient rainfall in average years a slightly diminished rainfall in any particular year may cause a great diminution in the crop of that region. This is the real danger to which grain-growing in the United States is exposed. In the old and thickly-settled countries of Asia, where the population has reached the limit which can be fed in average years, an excessive drought in any one year means famine and starvation; but in this country such droughts are but local, and mean only local misfortune, and for the nation at large diminished amounts for export. Bad weather at harvest, injuring the grain already produced, is not a common climatic misfortune, but the reverse, drought, and the consequent diminution of growth, are more frequent.

TABLE XXII.—THE DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE ANNUAL RAINFALL.

Inches.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Total	459, 470, 505	44, 113, 495	407, 858, 999	19, 831, 595	1, 754, 861, 535	11, 817, 327
Below 10	649, 998	831, 570	223, 200	2, 000	512, 322	....
10 to 15	2, 434, 514	2, 027, 390	1, 036, 591	36, 024	1, 346, 848	....
15 to 20	20, 969, 129	7, 222, 348	3, 812, 004	158, 451	1, 693, 748	18, 652
20 to 25	10, 641, 270	3, 203, 079	3, 118, 300	132, 195	5, 882, 078	14, 562
25 to 30	41, 437, 272	4, 142, 893	23, 311, 863	545, 050	63, 274, 162	55, 077
30 to 35	74, 071, 758	13, 368, 481	77, 052, 306	2, 741, 705	205, 070, 378	2, 216, 508
35 to 40	117, 902, 387	7, 578, 107	141, 857, 714	6, 997, 262	547, 072, 010	6, 598, 827
40 to 45	132, 152, 234	4, 750, 409	105, 417, 936	5, 683, 357	564, 623, 017	2, 005, 567
45 to 50	38, 240, 700	543, 102	30, 407, 330	3, 079, 798	205, 098, 096	862, 564
50 to 55	8, 642, 735	172, 805	10, 466, 574	193, 656	95, 883, 352	22, 017
55 to 60	7, 007, 590	26, 121	8, 072, 531	261, 083	55, 802, 135	21, 063
Above 60	4, 420, 000	246, 200	3, 082, 650	405	6, 734, 389	2, 400

TABLE XXIII.—THE DISTRIBUTION OF CEREAL PRODUCTION IN ACCORDANCE WITH THE RAINFALL OF THE SPRING AND SUMMER.

Inches.	Wheat.	Barley.	Oats.	Rye.	Indian corn.	Buckwheat.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Total	459, 470, 505	44, 113, 495	407, 858, 999	19, 831, 595	1, 754, 861, 535	11, 817, 327
Below 5	508, 841	412, 070	186, 000	878	337, 919	....
5 to 10	5, 303, 067	2, 140, 484	2, 827, 072	31, 930	718, 267	1, 398
10 to 15	23, 408, 505	8, 930, 371	4, 618, 498	206, 056	5, 101, 874	64, 447
15 to 20	145, 725, 021	20, 613, 375	108, 265, 213	3, 314, 168	312, 511, 933	2, 710, 452
20 to 25	220, 056, 637	11, 810, 787	261, 350, 653	15, 570, 424	1, 143, 239, 093	8, 084, 017
25 to 30	63, 424, 034	204, 748	27, 501, 154	687, 137	276, 062, 349	48, 018
30 to 35	303, 400	1, 110	2, 875, 700	14, 002	15, 097, 000	....
Above 35	....	....	167, 200	....	1, 192, 200	....

SOILS OF THE GRAIN-GROWING REGIONS OF THE UNITED STATES.

The geological structure of the country, except so far as it affects physical geography, exercises a minor influence on the distribution of cereal production. The profitable cultivation of cereals on a large scale is more dependent upon climate than upon soil, and in the United States the relative fertility of the soil is but a secondary factor in the matter of production. Rocks of various geological ages underlie the different portions of the chief grain-producing regions. The immediate influence of the underlying rocks is, however, greater in the southern and western portions of the United States than in the northern and eastern. A great variety of geological structure may produce soil of great fertility, but the production and distribution of grain in the United States is influenced more largely by the physical character of the soil than immediately by its chemical fertility. The portions producing the bulk of the grain have soils of reasonable fertility, but are also those which are easily tilled, and upon which the best machinery and labor-saving appliances can be most readily used. Regions where the use of the best machinery is attended with more difficulty, however fertile the soil, produce less grain, other crops being, upon the whole, more profitable.

While the geological character of the underlying rocks exercises but a secondary influence on grain-growing as it now exists in the country, we may say in a general way that most of the grains of the United States are grown on soils that overlie rocks older than the Jurassic. In New York and in New Jersey we have very fertile soils on the older Silurian, the rocks becoming newer as a whole as we pass west; in Ohio, Indiana, and Illinois we have the Carboniferous, until in Dakota, in some of the prairie regions, in the grain-growing regions of California and in those of Washington territory, the more noted wheat soils are on Quarternary rocks.

CLASSIFICATION OF SOILS ACCORDING TO ORIGIN.

While there is an infinite variety of detail in the character of the soils of the United States as regards physical qualities and chemical composition, they may be classed into three great divisions as regards their origin, and this classification in a measure also classifies them as to physical qualities.

Drift soils.—First are the drift soils of the north, occupying the principal portion of the states lying north of the Ohio and east of the Missouri river. It is a theory of geologists that in a previous age of the earth the northern hemisphere had a very much colder climate than now; that ice in the form of glaciers covered all the more northern latitudes and extended down into those portions of the United States already indicated, producing grand effects on the topography of the country, and at its close modifying and determining the character of the soil as far south as the ice extended, and possibly farther. Without discussing the details which have been the object of a large amount of study and the subject of an extended literature, suffice it here to say that the underlying rocks were at last covered with a deposit of variable thickness, known to geologists as *drift*. This consists of sand, gravel, clays of various composition and texture, stones more or less water-worn, all mingled in various proportions, and of various degrees of fineness. This drift, sometimes forming but a thin layer over the underlying rock, sometimes forming a very thick layer, is made up of the mingled materials brought from various geological formations lying to the north of the place where they are now found. The soils of this drift are usually gravelly, often stony, of variable fertility, embracing alike the noted fertile soils of Ohio and of western New York and the most barren portions of New England. As a whole, these soils grow finer as we travel southward and westward from New England and western New York.

As a whole, they are durable. When over-cropped and worn out even, as often occurs, they readily recuperate, with rest, by the decomposition of the mingled materials of which they are composed.

According to geologists, the southern limit of this drift-soil extends across Long Island, crossing New Jersey at its upper third; thence across the state of Pennsylvania, entering it and leaving it about midway, entering Ohio near where the Ohio river strikes the state, passing southwesterly, leaving the state near the Ohio river, following along the southern borders of Indiana in or near the southern tier of counties, not crossing the river at all unless it be for a very small region, where the three states of Indiana, Illinois, and Kentucky come together; thence westward, crossing the Mississippi above its junction with the Ohio; then westwardly and a little northerly across the state of Missouri, keeping south of the Missouri river, leaving the state at about Cass or Bates county, and entering Kansas in perhaps Miami county; thence northwesterly, crossing the Kansas river in Riley county, entering Nebraska at or near Jefferson county, crossing the Platte probably in Polk county; thence northwesterly to Holt county. West of the Mississippi river these boundaries are ill-defined, and in all of the western states there are large areas where the soil is so modified by other influences that agriculturally its drift character is reduced to almost nothing.

Second class.—The second great class of soils occupies the undulating parts of the country lying south of the drift. They have been made by the decomposition of the rocks which underlie them, or which have occupied their present position. The natural action of water, air, and the gases which they contain, along with varying temperature, is to disintegrate the rocks. Even the hardest will weather in the course of time. Some decompose rapidly, others more slowly, but all in such a climate as ours ultimately will be reduced to a soil. The immediate surface disintegrates more rapidly in a cold climate, where frost aids the process, but ultimate chemical decomposition goes on more readily in a warm climate than in a cold one, particularly if it have abundant rains. If a region is fertile and the climate admits, so that there is an abundant vegetation on the surface, which produces carbonic acid and other chemical products by its decay, these dissolve in the rain-waters, and then the decomposition goes on more rapidly beneath. If the underlying rocks are of limestone, then large quantities of the lime are dissolved out, and if the limestones are impure, containing much insoluble matter, the solution of the soluble carbonate of lime leaves a soil composed largely of the insoluble remains. Such soils are often of extraordinary fertility, illustrious examples of which are seen in the so-called blue-grass regions of Kentucky and in some of the more fertile prairies of Iowa.

Throughout the southern states, on the slopes and the uplands, we have a great variety of soils produced by the chemical and the mechanical disintegration of rocks, possessing every variety of character, both as regards chemical fertility and physical texture. Some of them, particularly when produced from certain sandstones, are poor and easily exhausted, and when exhausted do not recuperate readily, of which we have examples in some of the more barren land flanking several of the chains of the Appalachian system. Others possess great power for rapid recuperation, as, for example, the blue-grass region of Kentucky, where the calcareous portions of the soil rapidly disintegrate or are changed by chemical action, and where there is an abundant source of the elements of fertility in the rocks themselves. The state geologist of Kentucky gives interesting illustrations of this power. Certain areas inclosed within the region already described as being occupied by drift have been modified by these same influences. Professor Whitney, former state geologist of Iowa, states that some of the fertile prairie soils of that state—those where the soil is of almost impalpable fineness—have been produced by the slow solution of beds of limestone which formerly occupied their places. In the course of ages, under the influences already spoken of, the limestone has been dissolved, the solution borne away to the ocean in the rivers, and the small percentage of insoluble residue is left, forming the thick prairie soil of the region, which has since become blackened by the decay of the abundant vegetation produced upon it. From the nature of the case we have a very great variety of soils belonging to this class.

The third class is what is known to geologists as Quaternary deposits. They include all of the alluvial soils formed by deposition from rivers and streams, of which we have such abundant examples about the mouth of the

Mississippi. They constitute all the bottom-lands of the West, and indeed of the whole country. They also are found in places, particularly in the West, occupying the beds of ancient lakes; a notable example of which is in the fertile soils of Dakota, popularly known as the Red River region. Here was an ancient lake of very great size, known to geologists as lake Agassiz, extending southward to lake Travers, on Red river, widening northward and extending both sides of the river, perhaps 55 or 60 miles wide where its bed leaves the country, expanding to much greater width northward in Manitoba. This tract is exceedingly level, the soil of varying depth, very fine, black with the decomposition of vegetable matter, and very fertile. As we proceed westward, soils belonging to this class contain less and less vegetable matter, although not necessarily less fertile, until in the valleys of California we have in places soils of great fertility which contain very little vegetable matter indeed. The amount of vegetable matter coloring the soil black which remains in the soil depends very largely on the temperature, climate, and on the amount of water. There is little in a dry region or in a region subject to periodical droughts, and yet such a soil may be very fertile in the mineral constituents necessary for grain, and in seasons, with sufficient rain or by irrigation, very large crops may be grown.

These three classes of soils run into each other by insensible gradations. The classification is given as merely a general one. We may say in a general way that corn flourishes best on soils of the third class, and that it probably is mostly produced there, and wheat on the first and the third classes, more probably being produced on the first class. But individual soils of the second class are even more fertile than those found in either the first or the third.

A notable example of the soils of this second class is found on the table-lands of eastern Oregon and Washington; the underlying rock is volcanic, which by its decomposition has given rise to a soil of very great fertility and of easy tillage. The experience of the Old World, with volcanic soils about the Mediterranean and in the Rhine region, some of which soils have vineyards of great age upon them, indicates that these soils of eastern Oregon and Washington will retain their fertility for a great period, and it is probable will ultimately support a dense population and produce a great variety of agricultural products. This is now rapidly gaining as a wheat region. Barley and oats grow well, and are of most excellent quality, but the climate is unfavorable to corn.

The term "prairie soils", as commonly applied, is most indefinite, and includes soils of various origin. Soils originally "prairie" differ much in their physical and their chemical characters, and others not originally prairie very closely resemble some of the true prairie soils. The region of greatest cereal production in the United States is oval in outline, stretching westward from the eastern borders of Ohio about 800 miles, and is about 600 miles wide near the Mississippi river. This region includes the most noted of the prairie soils, and is nominally nearly all on the drift region of geologists. But there is a considerable variety of soil. In the eastern part, notably in Ohio, are more gravels, and the most of Ohio and much of Indiana was originally clad in very heavy forests. Portions of this originally wooded region closely resemble some of the prairie region in soil. As a whole, the prairie soils are finer than those that originally produced timber. Wherever gravel appears there was generally more or less wood, while soils of impalpable fineness were all of them naked of trees. The prairie soils as a whole, then, are very fine, some entirely destitute of stones or gravel, and others very nearly so, often very deep, containing considerable vegetable matter, and some of them of astonishing fertility, bearing an amount of cropping that seems incredible. Among the more fertile portions of this region are the bottom-lands, some of which were originally prairie, and some were wooded. As might be expected on such lands, there is usually more clay and greater fertility. Considered as a whole, these soils are not so much more fertile than the better soils of New York and Pennsylvania, or even of New England, as is popularly supposed; but they are vastly superior in the ease of their cultivation, and in the fact that great areas are susceptible of cultivation without intervening stretches of hills or less tillable land.

The various forms of prairie soil run into each other, the finer ones being those which are supposed to have been produced by the solution of limestone rock, leaving an insoluble residue of impalpable fineness as the present soil. Many of these are so fine that they will only slip on the most polished plowshare.

I may say, then, that in a general way the greatest production of grain in the United States is on soils easy of tillage, and not necessarily where the average crops are greatest. The most noted grain soils admit of light implements and rapid work. The most striking difference between American grain-growing and English grain-growing is in the use of lighter implements of culture and lighter animals used for field work.

As regards geological origin, mechanical texture, and chemical composition, there is great variety, all, however, agreeing in this, so far as I know, that all the more noted grain soils of the country are rich in lime.

It must be remembered also that grain-growing has changed under modern facilities for transportation. A few years ago Tennessee and Kentucky were much more famous as corn states than now; the ease with which corn is obtained from the states just north admits of the use of lands for cotton and tobacco, which formerly produced corn and pork.

So far as soil and climate are concerned, varying conditions of market, or new mishaps overtaking these commercial plants, may materially modify grain-growing in regions where now not much is grown. American agriculture so easily adapts itself to new conditions that regions now of secondary importance in grain production will come forward if for any cause grain-growing becomes more profitable.

HISTORY OF THE CEREALS.

DEFINITION OF CEREALS.

In a general way, all of those starchy agricultural grains or seeds which are used as food for man or his animals are called *Cereals*. In a more restricted sense the term is limited botanically to the seeds produced by certain cultivated species of the *Gramineæ*, or grass family, and the term is used in these two meanings, both in popular usage and in technical description. More specific definitions are numerous: "the agricultural seeds which grow in ears, not in pods;" "all sorts of grain from which bread is made;" "agricultural grains which are used for the food of man and his domestic animals, and which are produced in chaff or husks, and not in pods;" "a general name for all seeds used in making bread, especially the seeds of the *Cerealia;*" "the seed of certain grasses which are used for food for man and his animals from time immemorial, and called corn;" "the seeds of certain grasses like wheat and barley and certain other starchy seeds which may be ground into meal, like buckwheat," are some of the definitions found in the literature of the subject. But, however defined, the term is applied to what we call "*grain*", and what the mother country calls "*corn*".(a) They are the breadstuffs of the civilized world, and, however classified, all the different kinds have these characters in common, that they are starchy grains, which may be ground into meal or flour, and are capable of being made into some form of bread. While differing from each other in various chemical and physical characters, they have so many properties in common that their uses are largely interchangeable, and in different circumstances one takes the place of another in cultivation and in use. We may say that, as a rule, in all former times and until modern means of transportation came into use, the grain most largely consumed for bread in any country or region was the one most easily and most surely grown at home, or at least at no great distance away; the bread, of necessity, had to be made of such grain as could be grown or procured with the facilities then enjoyed. Rye, buckwheat, oats, barley, and millet had among our ancestors an importance as bread-plants that they have now lost and will probably never regain. This fact, apparently so obvious, and yet so hard to realize in practice, lies at the bottom of that agricultural revolution already alluded to, which is now going on everywhere among nations and peoples of our civilization, and most notably in western Europe.

The more important cereals have been known and cultivated from remote antiquity, and have so changed under the care of man that we are ignorant as to what their original wild progenitors were. After long and patient investigation by some of the most eminent scientists and historians, notwithstanding its important connection with the history of civilization itself, botanists up to the present time are not agreed as to what is the original parent species from which any one of our chief cereals has been derived, nor do we know the history of their subjugation to cultivation, or what succession of changes they underwent between their wild state and their present cultivated varieties. At the earliest dawn of written or pictorial history they were already, so far as we can learn, as completely changed from their original wild state as they are now. Even with some of the prehistoric nations of Europe we find several species of cultivated grains (wheat, barley, and spelt) mingled with the wild fruits and seeds which constituted in part their food.

These facts have led many good men to believe that the cereals never were wild plants existing without cultivation, but, instead, were the direct gift of God to man. Such think that they were not produced by man as a result of the long cultivation of a cruder original, but bestowed ready formed for man, as something necessary for his good and essential to his highest civilization, and at the same time dependent upon his labor and care for preservation and continuance.

Without discussing the various hypotheses proposed to account for their origin or for their history, it is sufficient for our present purpose to say that through the historic period each species has existed under so many widely different forms or cultivated varieties that naturalists have never been agreed as to what constitutes a species, nor as to the number of species of any of the more important cereals. The term species is reasonably definite as applied by naturalists to wild plants and to wild animals, but it never has been so definitely used or definitely understood when applied to the various breeds of domestic animals or to varieties of cultivated plants. Naturalists, as a whole, are agreed as to the genera to which the cereal grains belong, and the history of each will be noticed more in detail under their separate and appropriate heads, so far as they are of direct interest to American agriculture.

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a In this report, in accordance with American usage, and also with the language of statute laws pertaining to the grains in many of the states, the word "*corn*" is used as the specific name for Indian corn or maize, and the word "*grain*" as a general term for all the cereals. The terms "*an ear of corn*" and "corn in the ear" are also used in the American sense as applying only to Indian corn or maize, and the term "*head*" is applied to an ear of wheat, rye, or barley. Such use of these words is so common and universal in the United States that I have never heard a native-born farmer, farm-laborer, miller, or grain-dealer apply the term "*ear*" to the fruiting portion of wheat, barley, or rye, nor the term "*head*" to that of Indian corn. The American use of the word "grain" is not quite synonymous with the English use of the word "corn." We never apply the term "grain" to leguminous seeds, while in the annual agricultural returns of England beans and pease are returned under the head of "corn crops", rather than under that of "green crops".

Seven species (calling buckwheat a cereal) are cultivated in this country in sufficient abundance to be returned in the census tables, and three or four more are occasionally cultivated in a few localities. Taken altogether, these include all the more important cereals of the world.

In addition to these there are a number of other species cultivated here and there in other countries, each of some local importance, but all, except the few alluded to, are grown on a comparatively small scale, or restricted to few localities. Taken altogether, there are possibly twenty or more species cultivated somewhere in the world, the aggregate value of all the rest, however, amounting to less than the least of those known in the United States.

Of the seven species we have to deal with, six are natives of the eastern hemisphere and one of the western. No cultivated grain has originated on an island, if we except canary grass, and none in southern Africa or Australia, regions otherwise very rich, botanically, in species. Humboldt called it a striking phenomenon "to find on one side of our planet nations to whom flour and meal from small-eared grasses and the use of milk were completely unknown, while the nations of almost all parts of the other hemisphere cultivated the cereals and reared milk-yielding animals. The culture of the different kinds of grasses may be said to afford a characteristic distinction between the two parts of the world".

The genera to which the principal cereals belong are: *Oryza*, or rice; *Triticum*, which includes all the varieties of wheat and spelt; *Avena*, oats of various kinds; *Hordeum*, the various kinds of barley; *Secale*, rye; and *Zea*, Indian corn. Among the true cereals, that is, belonging to the grass family, there are various species of millet, belonging to several different genera (*Panicum*, *Pennicillaria*, *Emilium*, *Setaria*, *Holcus*, and *Sorghum*); durra, a species of *Sorghum* (called also Indian millet and Guinea corn, and spelled in various ways, as dura, dhura, doura); canary grass, *Phalaris*, and a few other species belonging to the grasses. In addition to these botanical cereals are the buckwheats, which, for convenience in this report, are classed among the true cereals. They belong to the genus *Polygonum*, two species of which are cultivated in this country, and perhaps others elsewhere. Several species belonging to the genus *Chenopodium* have been cultivated in various parts of the world, particularly in India and central Asia, but none are of importance to European nations as grains. Of a considerable list that might be made, wheat, rice, and Indian corn are the first three in importance; oats, barley, and rye next; then durra; the millets and buckwheats next; all of the remainder being of insignificant importance to the world at large.

However defined and classified, and however used, all the cereals are agricultural grains, all are starchy, all are breadstuffs, and all are annual plants.

Being annuals, they are adapted to almost universal cultivation where the summer climate admits, for "an annual plant may be said to belong to no country in particular, because it completes its existence during the summer months, and in every part of the world there is a summer".

This fact underlies the agricultural importance of the cereals. Every gardener knows that annuals may be brought from almost any country and be made to flourish in cultivation in any other country in which they can complete their life in one summer, and that, even if the summer is too short, varieties may be produced by art which will mature quicker, and then their cultivation may be extended to climates unlike that of their original home. This may be continued up to certain limits set by nature for each species, which limits can be determined only by experiment. Not so with perennials. They must have not only a favorable summer climate, but also a favorable winter climate and a favorable average climate, and, moreover, be able to stand occasional wide deviations from the average climate. The exceptional heat of one year or cold of another, a too wet season or a too dry one, may kill the tree or perennial which has lived and thrived for many years; hence all perennials are restricted in their growth to very much narrower limits than annuals. Moreover, annual plants are believed to be much more variable under different external conditions than perennials are. They vary more in nature, and it is among the cultivated annual species that we have the widest variation known to science. They can adapt themselves more readily to changes of soil, climate, and other variable conditions than perennials. Thus it is that the plains of Dakota and Manitoba, with their genial summers and fertile soil, even though the winters be of Arctic severity, and California, with its rainless summer but genial winter, can alike send wheat to the mild-wintered and moist-summered British islands.

These are, however, but general facts. In practical cultivation, however favorable all the natural conditions may be, the ultimate profit turns not only on the species cultivated, but on the special varieties; for in any grain-growing region some varieties of each species fail entirely; others live and flourish, perfecting themselves well as to quality, which still cannot be grown profitably.

VARIETIES OF CEREALS.

Each species of the cultivated cereals includes a great number of varieties, which differ as widely among themselves as species do in nature, and precisely like different species are adapted to unlike conditions of growth. As a consequence, only a few of the many varieties of one species will flourish in any one region or on any one farm, and still fewer can be cultivated in any one place with profit. Many that do not utterly fail may grow well and look thrifty, and yet not yield well, or the grain may lack in quality, or the crop be deficient in some way, so that practically the ultimate success of grain-growing in any place turns upon the varieties cultivated. What are the best varieties of each grain? furnishes a fruitful topic of discussion at every meeting of grain-growers, and is the subject of more experiment on experimental farms and by enterprising farmers than any other one thing. Indeed, the national Department of Agriculture really had its origin in the effort to put farmers in the way of getting new varieties of seeds for trial.

It is impossible to give a definition of varieties which will be accurate, comprehensive, and at the same time one upon which scientific and practical men will agree. This difficulty is largely due to the fact that the real pith of the discussion of the modern doctrines of evolution, Darwinism, and kindred topics, lies in the question regarding the nature of varieties, and particularly whether the distinction between them and species is merely a difference of degree or a difference of deeper signification. The general subject of varieties, their nature, constitution, origin, and permanence, is of such paramount importance in considering cereal production that a general discussion of it is necessary for an intelligent consideration of the production of the special crops.

That species and varieties change by cultivation, that new varieties are formed, that some do better than others, must have been noticed from the earliest times, and man probably learned some of the ways by which new varieties might be made or old ones improved almost as soon as he began to till the soil. It is only within the last few years, however, that their multiplication and improvement have been carried on with an intelligence based upon scientific knowledge and in accordance with scientific methods. Any intelligent discussion of the matter must be based on the deductions and conclusions of modern science.

The science of natural history begins with the comparison of living beings with each other and their classification, the unit of classification being called the *species*. The idea of distinct species in nature has had a place in all discussions relating to living beings from the very earliest times, and yet no definition has been devised, even to this day, upon which all naturalists will agree, either as to their origin, their nature, or their limitations. A discussion of this subject would not be profitable here, and I will only say that in a general way, and when speaking of the vegetable kingdom, naturalists are agreed that those individual plants which resemble each other as much as they resemble their parents and their descendants, and all those which are known historically to be descended from the same stock, form collectively a species.

For convenience of study, and for the better understanding of their mutual relations, scientists group the species having certain resemblances into genera, genera into families, and families into classes. Various systems of classification have been devised from time to time, but in all systems the unit of classification has been the species, however unsatisfactory the definitions and limitations of species may have been. According to any theory, however, a species consists of many individuals, and, although the individuals composing it die, the species lives on from generation to generation. "Each yielding seed after its kind" is the oldest description of a biological law which we call the law of *heredity*, the law which is the ever-acting conservative force which tends to keep the descendants, like their parents or ancestors, in continuous succession of specific characters.

But heredity is not the only force at work in the production and growth of the living plants. The seed is indeed a wonderful thing, very small when compared with the mature plant, yet stored in it are all the powers derived from parents and ancestors, reaching backward to creation, and all the possibilities of future generations. Nevertheless the powers of the seed are after all only possibilities; other influences must aid it, or its power and its life ends when it falls from the parent plant. Water must moisten it and the sun warm it, or it will never sprout; and if it grows, through its whole life the earth and air and sun play each their part in its growth and nourishment. Heredity gives direction to the growth, but it only partly controls it. All through its life those elements which nourish it also modify it. It is plastic in its nature and molded by them, so it naturally happens that the new plant is never quite like its parent. It may live in a better soil, and grow larger, or it may be starved and smaller, or other influences may help to shape it; but any new character it takes on becomes a part of its being, and then heredity tries to transmit this new character to the next generation. This is one reason why the individuals which constitute a species should differ among themselves, and why cultivation should tend to make the differences still greater, because art supplies conditions to influence the growth of cultivated plants which wild plants never find in nature.

There is probably also an innate tendency to vary inherent in living beings—a biological law opposed to heredity, weaker than heredity, always working with it, but never strong enough to overcome it. Whatever may be the cause, we see abundant variation, both in wild and in cultivated plants, which is not explained by any obvious external cause. For example, in any field of grain or other plants of one kind, however uniform the soil or the seed, we know that the plants differ among themselves, although all are nourished by the same soil and rains and air and sun. They differ in height, in vigor, in fruitfulness, in foliage; in fact, in all of their characters. These differences may be slight to begin with, and may be the beginnings on which to build new varieties. Regarding the actual *causes* of variation there has been much discussion.

One cause everywhere observed and universally recognized is the effect of nourishment combined with climate. The relative abundance of nourishment tends to variation, and by means of this alone varieties may be formed. For example, two measures of the same kind of grain, from the same bin, may be sown on two fields of unlike soil and fertility, and each continue to be thus grown for a series of years. In time this difference of fertility of the soil would cause the crop on the more fertile soil to be habitually better in every respect and the growth larger.

There would, in fact, be two varieties; and if these varieties be again sown side by side on the same soil, one would mature better and be larger and more prolific than the other, and the cause would be that it had been better nourished for a number of preceding generations. If this difference of soil had been combined with difference of climate, the effect would be still more marked. Climate, soil, abundance of nourishment, and other external conditions are universally recognized as the causes of variation by farmers and scientists alike, and some believe that all variations are due to such causes.

There is much evidence, however, that, as before stated, there is an inherent, innate tendency to change. For example, if we examine the individual plants in a large field of uniform soil covered with any crop, we find great differences between the individual plants. Some are larger, some smaller; some produce more heads, and some fewer, and so on through every difference of character, whether of root, or stalk, or leaf, or grain. If we select seeds from two plants differing in any character, no matter what, but for our purpose supposed to be the two having respectively the lightest-colored and the darkest-colored grains, and sow them separately on precisely similar soils, and the next year we again separate in each the lighter seeds from the one, the darker seeds from the other, and so on from year to year, every farmer knows that at length by such a process we would have different kinds, or, as we say, different *varieties*, each producing seed after its kind. Here the variations were not made by either soil or climate, nor, so far as we can see, by any difference of nourishment. There has been a variation, the cause of which, if there is any other cause than an inherent tendency to vary, is unknown. It is only fair, however, to state that some scientists deny *in toto* any such inherent tendency to change and refer all variation to the molding influence of outside forces, and claim that the plant is passive and plastic, and that the species is molded into shape entirely by the external forces.

Without further discussing the causes of variation, it is certain that there is a tendency for any character, however produced, to be perpetuated by heredity. Experiment has abundantly proved that if we select plants having any one variation, plant their seeds, and from the next generation again select the plants having the same peculiarity in the most marked degree, we will find that from generation to generation the successive crops, or at least some plants of that crop, will vary in that direction more and more from the original form, and in a few generations we will make a new variety, having that special peculiarity in an exaggerated degree. We add up the slight variations of successive generations until we have a large sum represented, and this characterizes a new variety. Many varieties have been produced in this way, and our fields and gardens are filled with the results. What the possibilities are of thus accumulating a particular variation no one knows, but what its applications are the race has known for thousands of years, for this is practically the only means we have of *improving* any variety of grain already in existence. The selection of the best seed for sowing, or the rejection of the poorest, has always been the great, and, strictly speaking, the only, method of improving grains. The careful selection of the seed has been recommended from the earliest times. Columella, Celsus, Virgil, and other ancient writers speak of it, while the rejection of the poorest is the way leading to the same result most often alluded to in the Bible. "Every tree which bringeth not forth good fruit is hewn down," "Cut it down, why cumbereth it the ground?" are illustrations; the end gained is essentially the same. The principle of improvement by the careful selection of seed is well enough known. There is not a grain-growing district in the world where it is not practiced, and yet no law is oftener violated, particularly where grain is grown on a large scale. The truth of the law is universally recognized; the only difference of opinion that exists among grain-growers respecting it is, how far it is possible to ignore it with not too great loss.

In this connection, there is often discussion as to the advisability of sowing shriveled seed or inferior grain of kinds usually good. Shrunken grain will germinate and often produce a good crop, but it will not produce as large a yield as plump seed, and if continued a few years in succession the variety is sure to degenerate.

There are several ways of propagating cultivated plants, and the method of propagation determines in one sense the nature of the varieties produced, and also the method of creating new varieties. The sexual method of propagation is by means of seed, but there are many non-sexual methods, as by grafts, buds, cuttings, layers, tubers, and bulbs, and the farmer often confounds these essentially different methods in practical application. The laws of heredity apply only to the first or sexually-propagated plants, and to these belong all the cereals.

Not every variation between plants of the same species constitutes a variety in either the botanical or the agricultural sense. It must be possible to multiply individuals having the desired character, for a variety consists of many individuals having some one character in common. A plant may vary from its fellows, no matter how widely, but if a new generation cannot be reproduced from it having its special characters we do not call that a "variety"; it is merely peculiar to an individual. With species which in cultivation are commonly propagated non-sexually (as by grafts, buds, slips, cuttings) new plants are easily propagated having the especial characters of the parent, and many gardeners' varieties of fruits, vegetables, and ornamental plants are so constituted. They are perpetuated by the methods spoken of, and not by seed. With such species the seedlings may vary enormously.

But the grains are grown only from seed; every plant is a seedling, and varieties of cereals are precisely analogous to breeds of domestic animals, in that they must breed true to their parents or ancestors, while varieties that are multiplied non-sexually, like apples and potatoes, need not be true to the seed. The characters which mark a breed of animals must be capable of transmission sexually from generation to generation, just as the special characters of a variety of grain must be; it must "breed true", as the live-stock breeder would say. Moreover, the principle universally recognized in stock-breeding, that an old breed, carefully bred and carefully selected, transmits its qualities with greater certainty than a new one, is equally true in respect to plants. This does not conflict with the fact that a change of seed is often attended with good results, for that is owing to another character.

Varieties of cereals not only differ in their characters just as the breeds of domestic animals do, but so far as we know they are originated in a similar way, and may be improved or deteriorated by similar methods. Inasmuch as they are grown from sexually-produced seeds, they are subject to precisely analogous laws of heredity and variation, and, moreover, excellence of character and profit of growth depend upon precisely similar rules, the same laws of nature and rules of art applying in both cases. A race-horse, to be successful on the course, must be, first, of a running breed and of well-selected parentage; second, must be of good shape and not injured by mishaps or accidents; third, must have been well fed during its growth and life; and fourth, must be well trained, groomed, and cared for, with care for all the artificial conditions of its existence. Precisely analogous are the facts as regards cereals. For the best success, in the first place, the variety must be a prolific one, and the seed well selected; second, not subject to the diseases and mishaps most likely to occur in that region; third, it must be well fed—that is, the soil must be fertile either by nature or by artificial manuring; and fourth, the crop must be well cared for—that is, the preparation of the ground must be well done, the crop well put in, tended, and harvested. Under special conditions, particularly in a new country, where the land itself is rising in value, there may be profit, and for a long time large profit, in the rearing of animals where all these conditions do not exist, and where the pasturage costs nothing and competition is not close, and the region producing much below its capacity; and also with the raising of grain crops: there may, under exceptional conditions, be large profits for a time without such care.

Illustrating the first point regarding excellence of seed, both as to its actual condition and its pedigree, there are numerous illustrations recorded; but the famous experiments of Mr. Frederick Hallett, of Brighton, England, may be taken as a good illustration. They were planned with so much intelligence, conducted with such patience and care, were so profitable in their results—the essential results have been confirmed in so many other ways and by so many practical men—that they are worthy of being quoted in this connection.

He began with a single head of wheat chosen irrespective of size or vigor, but of a variety producing a good quality of grain. The head was 4⅜ inches long, and had 47 grains, which were carefully planted in rows, one grain in a place, 12 inches apart each way. At harvest the plants were carefully compared, and the one with the largest number of heads was chosen, and the grains from the best head of this best plant were planted the next year in the same way; and this was continued year after year, choosing each time for seed the best head from the most prolific plant. At the first harvest the best plant bore 10 heads, at the second 22, at the third 39, at the fourth 52, the best head of which was 8¾ inches long, and bore 123 grains (*Jour. Roy. Agr. Soc.*, vol. XXII, p. 371, and plate).

This was the origin of the famous "*Pedigree Wheat*". Later, and in a similar way, he made the varieties of "*Pedigree Oats*" and "*Pedigree Barley*", all very prolific, and each becoming famous. He gave the name "Pedigree" to these varieties because his process was precisely analogous to that of improving live-stock by breeding to points and strengthening the heredity of the good points by pedigree. Still later he gave his riper conclusions (*Trans. Brit. Assoc. Adv. Sci.*, 1869, p. 113), drawn from his long series of experiments, in substance as follows: That every fully-developed plant, whether of wheat, oats, or barley, has one ear superior in reproductive power to any of the others on the plant; that every such plant has one grain more productive than any other, and that this best grain grows on the best ear; that the superior vigor of this grain is transmissible to its progeny; that by selection this superiority is accumulated; that the improvement is at first very rapid, but that in successive years it gradually grows less; that an improved type is the result, and that by careful selection the improvement can be kept up. Another paper on his pedigree system, read before the Farmers' Club at Birmingham, in 1874, giving many interesting facts, is republished in substance in the monthly report of the United States Department of Agriculture for August and September, 1874, page 381.

The practical fact underlying this relates to selection. "Natural selection" is undoubtedly the principle by which species are preserved, whether it accounts for their origin or not, and artificial selection of seed is the only method by which any variety of grain can be improved or even maintained. Without it the variety always either runs out or changes, how rapidly this takes place depending upon various circumstances. Although exact experiments in this direction on the cereals are of more commercial importance than on other crops, yet it so happens, from various causes, that crops less important, at least to this country, have been the subject of more experiment relating to the selection of the seed, by scientific men and by practical cultivators, than the cereals. There are many records of carefully-conducted experiments made on many kinds of cultivated plants, showing differences in the seed itself, in vigor, and in crop-producing power. Dr. Gustave Marek has published a long account of experiments made by him at the agricultural experiment stations at Halle and at Leipsic, in Germany. Experiments were made with beans and pease, small and large seeds of each kind being planted on adjacent plots. The larger, better, and more uniform growth of the larger seeds was very plainly to be seen. He gives tables of the results, and the superiority is shown in every particular—in the height of the plants, number of seeds, number of pods, luxuriance of growth, weight of plants, weight of seeds produced, quality of crop; in fact, every desired character was in favor of the larger seeds.

Professor Lehman, of Munich, in Bavaria, has carried out a somewhat similar series of experiments with even more striking results, showing the effect on the crop of using large, plump, well-formed seed, as compared with using smaller seeds produced by the same plant.

Professor James Backman, of the Royal Agricultural College in England, has experimented with the seed of malformed and misshapen crop roots (*Trans. Brit. Assoc. Adv. Sci.*, 1862, p. 97). He found that when seeds derived from misshapen turnips and parsnips were used they produced even greater deformities than the parents presented. I cannot go into the details of his work, but his deductions are of value to us. The conclusions drawn from his experiments were, in substance, that a degenerate progeny will, as a rule, result from the employment of seed from badly-grown roots; that, beside producing ugly, malformed roots, the degenerate seed does not produce nearly so large a crop; that by selection we may produce well-shaped roots and increase the probabilities of getting the best crop, and that by designedly selecting malformed or poor roots we may produce seed which will result in a greater degeneracy.

Darwin cites his authorities (*Animals and Plants under Domestication*, II, p. 243), saying that in France since the cultivation of beets for sugar the plant has almost exactly doubled its yield of sugar, and that this has been effected through the most careful and systematic selection, the specific gravity of the roots being regularly tested, and the best roots saved for seed.

It is unnecessary to multiply further proofs, because all experiment points the same way, and the law is universally recognized. I have merely cited a few out of many scientific experiments. The principle is never denied; it is simply too often neglected in practice. In this connection it is well to remember that it is easier to deteriorate a crop by using bad seed, or even by simply neglecting the selection of the good, than it is to improve an already good variety; the down-hill road is the easiest traveled. The selection of seed to keep up the vigor, and the fruitfulness of the varieties cultivated, are more important than fertility of the soil as factors in permanent grain-growing. The matter of soil exhaustion is so well known that it is the staple argument with the majority of popular writers and speakers on agriculture; but, so far as I have personally seen or have been able to learn from the observation or the experience of others, in every locality in this country where wheat-growing has suddenly risen to large figures the quality and the yield have diminished more rapidly from carelessness in the selection of the seed and in the care of the crop than from mere soil exhaustion.

One method by which new varieties are originated has been given, namely, that of building it up by slow growth, by the addition of successive changes in the desired direction which were slight in any one year. But valuable varieties have originated in other ways than this, and from a kind of variation called "*sporting*", which is more familiar to gardeners than to grain-growers. It is a wider departure from the parental type, appearing suddenly, the ultimate cause of which is undetermined. A few examples, chosen from plants other than cereals, will best illustrate the subject. When the giant trees of California were discovered the seeds were in great demand, and in a few years millions of seedlings were growing in the various nurseries of the world. In one foreign nursery, among some hundreds of thousands of young seedlings, a single one was found with white silvery foliage, from which a variety was propagated by cuttings. The original plant of this variety we call a "*sport*", and we are entirely in the dark as to what caused that one seedling to vary so widely from all the other millions of its brethren. I have cited this example because of the fame of the tree, because the species had never before been subjected to cultivation, and because it was a species very old in the history of the world; hence the deviation from the line marked by heredity is the more remarkable. But sporting is common among all classes of plants; any one may see examples, and the books and newspapers devoted to gardening are full of accounts of them. One observer tells of a thorny locust growing without thorns; another of a seedling strawberry with simple leaves; another of some plant with peculiar flowers; sometimes it is a variation in the habit of the plant; in another, of the foliage; at another, in the flowers or in the fruit. In fact, it may be a variation of any character or organ, or in several features at once. It is frequently seen in wild plants, but is much more common in cultivated ones. If, now, we propagate from a sport, and if the new generation has the same characters as the parent, we have suddenly a new variety. Many well-known ornamental plants, fruits, and vegetables (which are propagated non-sexually) were so originated. Gardeners are well aware that sporting may be artificially induced in a variety of ways and at will, and multitudes of varieties have been produced by the ingenious arts of cultivators. But as all the cereals, as before remarked, are produced from the seed only, the more remarkable examples of sporting are of secondary interest to the grain-producer. Two matters pertaining to it are, however, of direct interest, the first relating to varieties which have originated from some single plant, the other to those varieties popularly known as hybrids.

While there is no absolute proof that any variety of cereal has ever originated in a sport, nevertheless the indications are that some have so originated. The new variety of Bamia cotton originated in a single plant entirely unlike its fellows, found in a cotton-field in the Nile valley in 1873, and the variety has already nearly revolutionized cotton culture in Egypt (*McCoan, Egypt as It Is*, p. 187, and *Kew Rep. for* 1877, p. 26, Fig. 7). Cotton is propagated from the seed as the cereals are, but the plant being a more conspicuous one, a sport would be more liable to be noticed. A single cereal plant, unlike its fellows in a great field of grain, would be gathered unnoticed unless some very unusual accident secured its preservation.

It is well known, however, that many varieties of grain have originated in some single plant differing from its fellows found growing in some exceptional place, but how that plant acquired its special characters, whether suddenly, as sports do, or not, we have no knowledge. We simply and only know that here and there some single plant has been found that represents to us a new variety ready made, and varieties have been perpetuated from such plants which have grown true to the seed and which have been valuable and enduring. The variety of oats known as "potato oats" is said to have originated in a single plant found growing in a potato-patch (hence the name) in Cumberland, England, in 1778 (*Allen, New American Farm Book*, p. 163), or, as some say, in 1789 (*Stephen's Farmers' Guide*, I, 449). The variety, after nearly a hundred years' existence, is still one of the best, and brings, it is said, the highest price in the English markets. Its excellence has been proved throughout Europe and entirely across the continent of America, for it is in common cultivation from Maine to Oregon and Washington.

The Clawson wheat originated in a single plant found growing by a stump in the state of New York. Darwin says that the Fenton wheat was found growing on a pile of detritus in a quarry in England. The Chidham wheat originated from an ear found growing in a hedge in the same country, and numerous other examples are recorded in the agricultural literature of this century. It is only fair to say, however, that many varieties of such origin have been rejected on trial as of no value, just as numerous varieties of seedling apples and potatoes are rejected. It is only the few that are actual improvements on what we had before. In ornamental and other garden plants the tendency to "sport" is much increased by crossing varieties, and this is probably also true of all classes of cultivated plants.

CROSSED VARIETIES, OR HYBRIDS.

It is now sufficiently well known that the flowers of plants are the organs of generation. This fact, suspected long ago, was proved by Linnæus about the middle of the last century, and it is now a matter generally understood that for a true seed of any kind to be produced it is necessary that a certain organ called the ovule be fertilized by a certain other called the pollen. The ovule is the rudimentary seed, contained in that part of the pistil called the ovary, and connected by tubes with another part of the pistil, which is without cuticle, called the stigma. The parts of the pistil are sexually the female organs of the plant. The male organs constitute the stamens, the essential parts of which are the anthers, containing minute grains called pollen. The matured and perfected seed always contains an embryo, which is a new rudimentary plant of the same species, which embryo is usually surrounded with an accumulation of starch or of some other substance adapted to nourish the young plant when the seed germinates. The embryo is the essential part of the seed, and this is only produced after sexual fertilization. The process is, that at the time of flowering the pollen falls upon the stigma; a tube then grows from its side down into the tissues of the pistil to the ovule; the fluid in it, with minute grains suspended in it, is carried downward in the same way, and the ovule is fertilized. If not, the seed never develops. This sexual production of the embryo of a new plant, as already explained, is closely analogous to the breeding of animals, and just as breeds of animals may be crossed so varieties of plants may be crossed by the pollen of one variety falling upon the stigma and fertilizing the ovules of another variety. Where different species of animals breed together we call the result a *hybrid*, and where different but well-defined breeds of the same species breed together we call the result a *cross-breed*. A few species of plants are fertile between themselves, and hybrids may be produced. Those curious in this matter will find an abundant literature upon the subject, the result of a large number of carefully-conducted and long-continued experiments, on which a vast amount of labor and study have been expended; and it has been abundantly proved that as with hybrid animals, where such hybrids are not actually sterile, there is in all cases a diminished fertility. In modern times new varieties of cereals have been produced by gardeners and cultivators by the artificial crossing of various varieties, and these cross-bred varieties have been called "hybrids". They are cross-breeds rather than hybrids. There are other gardeners' varieties, however, that are true hybrids, made by crossing distinct species, and which are propagated non-sexually; but, so far as our grains are concerned, all of the so-called hybrid varieties are merely cross-breeds, and not lacking in fertility. For an understanding of these it is important that we understand their essential characters and what natural laws are involved. As the same laws of heredity and of variation are involved which we find in animal life, we may draw some inferences from the analogous experience we have with cross-bred animals.

The crossing of different breeds of live stock is extensively practiced, and it is the common experience that for one or two generations the resulting cross-breeds may be superior to either of the parent breeds in useful qualities, but that they do not continue to breed true, and after a few generations are liable to lose some of their better qualities, and they cannot be depended upon for uniformity of excellence. Every stock-breeder is familiar with this general fact, and on it is founded the high price which thoroughbred animals bring compared with that of grade or cross-bred animals, which, for other use, may be just as good. An analogous class of facts exists with regard to grains. It has been the experience of numerous farmers, and long observed, that by sowing several varieties together an increase of crop may be produced, but that in most cases this cannot be long continued with profit. Two, three, or even more varieties of corn may be planted together, and the aggregate production is usually increased. But in all of those cases where I have specific information, if the seed produced by this mixture be planted for successive years, very soon, in three or four years at most, the crop deteriorates. I have been collecting evidence on this point for many years, and this experience is very common, if not universal. Sowing different varieties of wheat together is not so often practiced, but it is sometimes done with excellent results at first. So far as I have been able to learn, the same rule as to ultimate degeneration holds with this as with Indian corn, but the evidence is not so abundant, and is not conclusive. Sowing different varieties of oats together is a very old practice. Farmers in Scotland have long practiced it, and the quantity produced from such mixture is frequently a very considerable advance on either variety sown separately. The old theory was that where the several varieties were sown together they needed slightly different ingredients from the soil, and had slightly different habits of growth; so they covered the ground better and closer, and in this way the crop was increased. This doubtless is true, and has its effect, but it is more probable that the increase is more largely due to the crossing of varieties. In New England and in the middle states there are many farms where the same variety of Indian corn has been cultivated thirty years, sometimes even much longer, the variety carefully preserved and kept up by selecting the seed year by year at every harvest. Numerous experiments have been related to me where fields have been planted with a mixture of two, three, or four kinds together, one or two of which were these old improved varieties (whose characters were analogous to those of thoroughbred live stock), with perhaps some large variety of western corn; and in such cases the first and the second crops would be increased, sometimes very considerably; the third crop would sometimes be a good one, but rarely the fourth. The most common form of deterioration is said to be that a larger proportion of soft corn is produced, and thus in a very few years this mixture would run out, or at least become unpopular, because of the relative increase of unsound corn.

With plants, just as with animals, it seems that either too close or too wide breeding is attended with some evil results; and the best immediate results are attained by cross-fertilization. Various observers have called attention to the efforts on the part of nature to secure a considerable amount of crossing between different individual plants of the same variety, and of late years numerous papers, memoirs, and books have appeared, giving the most lengthy details regarding the special manner in which various plants fertilize their seed and the efforts which nature appears to make to prevent too close fertilization. Some species are fertilized only through the agency of some certain species of insects; others by insects in general; some have curious devices to insure cross-fertilization through insects visiting first one flower and then another, and some are fertilized simply by the wind; that is, the wind bears the pollen from the anthers to the stigma. This is the case with the cereals, none of which, so far as we know, are especially fertilized by insects, although, of course, individual plants sometimes may be. An abundance of pollen is produced, which is wafted to its place by the wind; the pistils are feathery in some of the grains, and thus more readily catch the pollen, and in one way or another there are special arrangements for securing this end. Observations are lacking to show whether the anthers and the stigma develop at the same time, or at different times, on the same plant with the most of our grains; but, so far as observation goes, it indicates that they come to maturity at slightly different periods, and in this way cross-fertilization is secured. It is only lately that attention has been turned to this question, and it has been found, particularly in some varieties of Indian corn, that on a given plant all of the pollen will be shed before the silk (the fibers of which are the pistils bearing the stigmas) is developed, thus insuring cross-fertilization by taking pollen from a later plant. The mixing of varieties of corn on the ear, particularly where they are of various colors, is a fact of such common observation that it needs only mere mention here to illustrate the principle involved.

Considering further the analogies between animal and vegetable life and the crossing of varieties, it is understood among breeders that certainty in result is secured in the offspring in proportion to the purity of the blood and the length of the pedigree of the parentage. It is for this reason that pedigrees are carefully preserved, and that herd-books and similar records are used. Also, that vigor is enhanced by breeding between animals of the same breed, but not constantly between those of near kin; that the wider and more varied the ancestry the more uncertain the results, and that with close breeding there is more uniformity of result; and, moreover, that breeding from animals of defective form, even if of good breed and good family, should never be practiced if we would achieve the best results. Now the experiments and the experience of each year bring out more and more strongly the analogies between these facts and what we observe in the growing of cereals (the experiments of Mr. Hallett are specially to this point), and just in proportion as the natural laws are well understood and grain-growers are convinced of their truth, in the same proportion will the uncertainties connected with grain-growing be lessened. Many of the conditions of growth will ever remain entirely beyond our control, hence the importance of attending to all those conditions which we can control.

We see from the preceding statements why the deterioration of grain crops should take place when they are not carefully cultivated, no matter how favorable the region for cultivation. All improved varieties are very artificial productions. If not actually made by art, they have been at least improved by artificially controlling the conditions of growth. Now the same plasticity of nature which made improvement possible also carries with it the capabilities of degeneration, and unless the same kind of care is exercised to maintain the variety which has been exercised in its production or in its improvement then the variety must deteriorate or run out. Whenever, therefore, a variety has been improved by the better selection of seed, and by its better cultivation, this variety, because of its pedigree, may carry its excellence when carried to a new farm or a new region, but is certain to degenerate under neglect, and the higher the degree of improvement the more rapid the degeneration.

From what has been already said, we are led to infer that the varieties of grain produced by so-called hybridization need especial care in their cultivation, at least until their characters are well fixed by heredity and by careful selection of the seed. But positive knowledge is meager on this subject, except as derived from interested parties. On a small scale success has attended some of these varieties, but I lack the information from disinterested observers as to its success on a large scale or for a considerable series of years. There is no reason why, with the requisite care, varieties may not be thus produced of great permanent value, just as valuable breeds of animals have been created by judicious crossing at first, followed by long and careful selection to fix the desirable points.

CHANGE OF SEED.

Using seed which has been grown in some other locality, or, as farmers say, "a change of seed," has been practiced by grain-growers in all ages; and that this is very often attended with an increase of crop has been proved by the experience of centuries. Sometimes this change of seed means bringing in a variety new to the region or to the farm; at others it is merely a change of seed of a variety previously cultivated there, by bringing it from some other place more or less distant.

However, in the light of our present knowledge, we see several causes why there should often be an increase of crop along with such change. Whether or not all variation comes from the influence of surrounding conditions of soil, climate, and cultivation, and whatever may be the origin of cultivated varieties, this much is certain: That all varieties have a local origin, and in all cases are more or less local in their preferences; that is, each one will grow in some one locality or region better than anywhere else, and from the very nature of the case all varieties are restricted in their adaptability to different localities. Some never flourish well beyond a very limited region. Others are susceptible of wider cultivation (as, for example, the potato oats, already spoken of), but all varieties are comparatively restricted in their range. Hence, each and every one of them, from the nature of the case, has its favorite home. But it very often happens that some variety will do well for a time in a region where it will inevitably run out if the cultivation is continued there and the seed is not changed from time to time. Every farmer is familiar with some such cases. The variety acquires in one place a sort of momentum of excellence, which it carries to a new locality—a store of vitality which is retained for a few generations in a less congenial home. We are more familiar with examples of this in garden vegetables than with cereals. To illustrate: potatoes grow well as far south as Louisiana, the Bermudas, and other warm climates if the seed is yearly brought from a cooler region. The same fact is true of pease, and there are large importations of seed-pease from Canada to the United States every year. Most garden vegetables behave in a similar way, and on this fact the modern business of growing garden seeds is largely founded. In Connecticut onion-seed is imported from Tripoli. The first crop grown from this seed is of such excellent quality that the trouble and expense of the importation are justified; but if the cultivation is continued from seed produced by the American crop, in a few years the onions degenerate to the size of acorns. The constant sending of the seeds of squashes and other garden vines from the New England states and other places east of the Appalachians to the fertile prairie soils of the West is another familiar illustration, and similar facts have been observed all over the world. Melon seeds from Thibet are taken every year to Cashmere, and produce fine fruit, weighing from four to ten pounds; but vines growing from the seed of melons produced thus in Cashmere yield the next year fruit weighing but two or three pounds. Seed of the sea-island cotton has been carried to every cotton-producing country of the world, but the variety rapidly degenerates in every place yet tried distant from its original home, and if the excellency of the fiber is kept up elsewhere it is only done by the use of fresh seed. A multitude of examples can be cited illustrating the same great law; the number of such cases and their economic importance makes the professional seed-grower of one place a necessity for the most profitable market-gardening in another locality. The more cosmopolitan the cultivated species is the larger the number of its varieties which flourish well in one place but degenerate in another. This great natural law includes the cereals, and is one explanation why a change of seed is often beneficial; but it does not explain each specific case.

As already said, there are several causes why a change of seed is often beneficial. The above-mentioned, based on what is known as "regional influence", is but one of them, and does not apply to all cases; and it is well to remember that in many cases a change of seed is not attended with increase of crop. Where the variety has been made in any one locality, or greatly improved there by careful selection of seed and good cultivation for a long time, the very "improvement" is one in special adaptation, and it must be carried out in a region not near the climatic limits reached by the species. This assumed improvement implies special adaptation of the crop to the region, and also implies that, with care, the crop may be permanently cultivated in that place, and that it will not necessarily deteriorate from the influence of surrounding conditions, as in the case of the varieties already spoken of, which do deteriorate because the surroundings were but partially favorable. Now it often happens that such a variety, specially prepared for a region by a long process of adaptation, may be better suited to it than any new one, and in such cases no increase of crop follows a change of seed. For example, heavy oats taken from the cool, moist climates of Canada or of northern Europe, used as seed in the northern or middle United States, usually produce at first a crop weighing more per bushel than that produced from home-grown seed. But in various places, notably so on Long Island, where special varieties have long been grown from seed carefully selected as to weight until this weight reaches that which is produced from foreign seed, no increase of weight is obtained by any change of seed. This appears to be the case in several localities reported. Another example to the point is in the local varieties of corn sometimes cultivated on farms in New England and the middle states. Where a single variety has been cultivated for a man's lifetime in the same neighborhood, or even on the same farm, each year the seed having been carefully selected and prepared until no further improvement is reached by such selection, there it often happens that such home-bred local variety yields better than any variety introduced from without. But it also happens that, having been so long purely bred, it is of especial value in mixed planting, as already described. Further illustrations of regional influences will be given under the special grains.

The tables of cereal production by physical moments (as temperature, rainfall, and elevation), appended to this report, will furnish the data for the after study of the relations between the production of each grain and the separate physical conditions which together constitute "regional influence". Such data have not heretofore existed. This work of Mr. Gannett is in a new direction; nothing of the kind, or even similar to it, has been done before, either in this country or elsewhere, on any such scale. The care with which these tables have been prepared, the magnitude of the facts thus tabulated, the nature of the conditions and details involved, give them an especial interest in this connection, and they promise to be of vast economic importance in enabling us to study, as they never could be studied before, the relations between special varieties and the physical conditions under which they attain their greatest excellence. It is eminently probable that further study and future observations in this direction will disclose relations between certain varieties of grains and the physical conditions of the several grain-growing regions which will result in a more intelligent selection of seed for a change and explain many anomalies observed by farmers, some of which will be noticed under the respective grains.

Another reason why change of seed is sometimes beneficial is that the diseases which afflict our crops, and the insects which prey upon them, prefer some varieties to others, and the diseases or the insects will become most abundant in those localities where the varieties they prefer are most cultivated. If, then, a new variety is introduced, even of itself no better in other respects than the old one; if it be less liable to mishap by insect or by disease, there is an advantage in introducing it. Other reasons of less significance exist, which will be noticed in their appropriate places.

Questions 40, 91, 119, 120, 121, and 122 of the special schedule relating to cereal production were especially directed to elicit information regarding the experience of farmers in respect to change of seed, the results of which inquiries will be discussed in their appropriate places.

We have so many cases where varieties of grain may be profitably grown with a frequent change of seed in regions where the varieties cannot be maintained without such change, the cases are so numerous, so marked, and the deterioration is so certain, that many farmers have come to believe that it is a law of nature that varieties will ultimately run out in every place if the seed is not changed. This subject has already been discussed, but we will repeat in this connection that there is no reason in nature why a variety should run out any more than why a natural species should run out or a breed of animals run out. We know of no reason why it should run out in a region to which it has been specially adapted, or where it originated, if the cultivation of the crop and the selection of the seed be maintained. Some varieties we know are very old, where artificial cultivation and selection have as really adapted the variety to a region as nature has adapted her species to their regions. The King Philip corn is believed to retain still the characters it had in the earliest days of the New England settlements.

PHYSICAL AND CHEMICAL CHARACTERS.

RELATIONS OF GRAIN TO MOISTURE.

All growing plants contain water in large quantities as a necessary constituent of growth. We have no full and continuous series of determinations of the amount of water in the cereals while still growing, and in the milk and in the dough, but all farmers are familiar with the fact that they are then soft; that as ripening goes on the juiciness of the kernel diminishes; and that finally, in our eastern climates, even when the grain is fully ripe, it is still so moist that it must be further cured before it can be safely thrashed and stored in granaries. But, however well dried in the air, all cereals still contain water, although they may appear dry and hard. When damp grain is exposed to dry air, the rapidity with which it dries and the amount of moisture which will remain in the grain after drying depend upon the dryness of the air and on the temperature at which the process goes on. In making chemical analyses of grains, flour, and the like, the amount of water is determined by drying the material at the temperature of boiling water or above. Some chemists dry at 212° F. (100° C.) until the grain ceases to diminish in weight at that temperature, others using a somewhat higher temperature. The conditions used in the analyses made for the Census Bureau were that the drying was done in a vacuum and at a temperature of 230° F. (110° C.).

All the commercial grains, then, as dried for market, contain a considerable but a variable amount of moisture. The tables of chemical analyses of American grains appended to this report show the amount found by the chemists in the samples of grains as they came into their hands. These tables extend to upward of two hundred analyses of grain in the kernel, and the average amount of moisture (or "water", as it is called in the analytical tables) is about 11 per cent.; the range, however, is large, running from about 4 per cent. to nearly 21. Great as is this range, the actual variation or range of the amount of moisture in commercial grains is undoubtedly considerably greater. There has never been any direct determination of the amount actually existing in the drier grains in the central valley of California, where, as is well known, grain becomes exceedingly dry in summer; nor, on the other hand, has there ever been any determination of the greatest amount that grain may contain and still be dry enough for purposes of shipment or of grinding. It is known that corn, as it comes to market, has sometimes 20 per cent. of water. As it comes into the hands of the chemist for analysis, it generally happens that it is selected grain of excellent quality, very frequently having been put up in small samples, and possibly kept in dry rooms for some time; it is therefore very frequently dried much beyond the point at which most of the grain is sold in the markets. When moist grain dries, its ultimate dryness depends upon the temperature and the dryness of the air. It continues to lose in weight more and more slowly, until a point is reached where there is no further loss, although there still remains several per cent. of moisture in the grain, unless it be driven out by a heat equal to that of boiling water.

HYGROSCOPIC CHARACTERS.

In common with most other vegetable substances, grain is hygroscopic, the amount of moisture contained in it depending upon the dryness of the air, the dryness of the grain fluctuating with its dryness, so that when moist grain is put in dry air it loses a part of its moisture and shrinks in bulk and in weight, and when dry grain is put in moist air it then absorbs water from the atmosphere and gains in weight and in bulk; if the air again dries, the grain again loses weight, the weight of the grain at any time being related to the moisture in the air which surrounds it. No matter how old or how new the grain is, it may be kept year after year, increasing in weight whenever the air is damp and moist and diminishing again whenever the air is dry, and these fluctuations in its weight, so far as we know, go on indefinitely; they certainly do for several years.

This subject has attracted but little attention in the Atlantic states, but has been the subject of much discussion and of some experiment in California, where it is a matter of relatively greater importance. The most of the grain of that state is raised in the interior valleys, and is generally stored there for a time before shipment. In those valleys the air is intensely dry during the summer season, and the grain loses nearly all of its moisture; and when this grain is removed to the damp warehouses about the bay of San Francisco, or is shipped to a foreign port in the hold of a vessel in which the atmosphere is nearly saturated with moisture, the weight very materially increases. It has been stated that "this increase will sometimes pay the entire cost of freight from San Francisco to Liverpool".

The actual amount thus gained has been the subject of newspaper discussion from time to time in that state, and to throw light on the matter Professor Hilgard, of the University of California, directed a series of experiments, which were conducted by Mr. Edmond O'Neill, of the Agricultural College of that university, who made it the subject of his graduating thesis, and an abstract is published in the *Supplement to the Biennial Report of the Board of Regents* of the university, of 1879, page 110.

His method was this: The dried grain was spread out in a very thin layer upon a small table, standing in shallow water and covered with a bell-jar. To make the air within this space as nearly saturated as possible, filter paper, dipping into the water below, extended to near the grain, but not touching it; the whole was kept at a temperature of about 64.4° F. (18° C.), and the grain was weighed from time to time in a corked flask to prevent loss during the weighing. Under such circumstances grain would continue to absorb moisture and increase in weight from twelve to eighteen days, the absorption being accompanied by an increase of bulk, which was not measured. The gain in weight from such absorption was as follows: In eighteen days oats gained 19.8 per cent.; barley, 20.4 per cent.; and in fourteen days wheat gained 18.8 per cent. In all cases the increase was very rapid at first, then slower and slower, until about the thirteenth or fourteenth day, when a sudden increase occurred, due to the development of mold caused by the great amount of moisture present. Nearly half of the total increase occurred in the first twenty-four hours, and the progress during the whole period may be seen in the tables cited.

He also exposed air-dried grain to an absolutely dry (artificially dried) atmosphere at the same temperature, and for the same period, eighteen days. The loss was at first very rapid, then slower and slower, but continuing for the whole period, amounting in eighteen days to 9.3 per cent. for oats, 7.8 per cent. for barley, and 6.2 per cent. for wheat.

According to these determinations, perfectly dry grain (artificially dried), exposed to a saturated atmosphere at a temperature of 64.4° Fahr. (18° C.) for eighteen days, will increase in weight as follows: Wheat, 25 per cent.; barley, 28.2 per cent.; oats, 29.1 per cent. As the temperature of the interior of that state in summer is about 80° F., experiments were made in drying grain at that temperature; and as the temperature increased, the amount of moisture thus lost in a given time also increased. Wheat dried in an artificially prepared atmosphere, believed to be about as dry as that which naturally occurs at harvest in the interior valleys of the state, led to the belief that the wheat cured there in the fields at harvest time becomes nearly as dry as it would in an absolutely dry air, and "on transporting to a temperate climate may possibly increase 25 per cent., while a gain of 5 per cent. to 15 per cent. may be looked for with almost absolute certainty". The profit of this gain in weight accrues to whoever owns the grain when this absorption is going on. When the farmer sells his grain by weight in those interior valleys, then this profit accrues to the commission merchants or dealers who own it between the time it leaves the ranches and the time when it is weighed in the foreign ports where delivered.

The atmospheric conditions in the Atlantic states are very different from those of California, but as the same law of nature operates similar changes occur. Because of the commercial importance of this subject, and the lack of knowledge as to the amount of water that commercial grains can or will absorb or lose during transit and handling in our climate, a series of experiments was begun by me in March, 1880, and before I was aware of those being made in California under the direction of Professor Hilgard. My method is this: Samples of grain of various kinds are kept inclosed in paper boxes, and the grain itself is carefully weighed from time to time on a chemical balance, with all the precautions to secure accuracy. The boxes containing the grain are but partly filled, and are kept in a basket suspended from the ceiling in my office, a second-story room, where the air of the room freely circulates about it. The temperature and the moisture of the room during the time of the experiment has been in winter that of an ordinary furnace-heated house in New England—a condition where the air is drier than in the warehouses, but not drier, probably less dry, than in the valleys of California in the time of harvest, and perhaps not much, if any, drier than occurs in the heated harvest fields of the Mississippi basin. The windows of the room were kept open during the summer and until the building was heated in the fall. New Haven is a seaport, and the air, although moist in summer and autumn, is not nearly so moist in such a room as it is in many places where grain is stored after it leaves the farm and before its shipment, certainly not so moist as the hold of a ship during its voyage. The samples exposed to these conditions were repeatedly weighed at various seasons of the year. Some varieties were also exposed to air dried over strong sulphuric acid in a desiccator, such as is used in chemical laboratories, and left standing in the sun for two months in summer, and a few samples of wheat still further dried (as it is in chemical analysis) in a vacuum at 230° F. (110° C.).

The samples were put in the boxes and the experiments begun in the early spring of 1880, when the most of the grains were thoroughly air-dried by being kept in the house the previous winter. They gained as warm weather went on from 2 to 5 per cent., according to their dryness when put up. They were not weighed between June 1 and September 10 of that year, and it is possible that they may have been heavier at some date in the interval than when weighed at the latter date, which represents the greatest weight in the summer of 1880. From this time their weights diminished until February, 1881, then fluctuated somewhat when near the minimum (and indeed they fluctuated all the time with each change of weather), and then increased again, attaining a maximum late in August or early in September of 1881. It will be remembered that this last date was in a period of unusual heat and drought over the whole region from the great plains eastward to the Atlantic. This severe drought existed at New Haven, and therefore the maximum weight reached was in a "very dry time", with the specimens inclosed under conditions like those pursued by seedsmen for the best protection of seeds from undue moisture without actual exclusion from the air.

It must be remembered that the term "dry air", as ordinarily used, is a relative term, not depending on the actual amount of moisture in the air, but the amount as related to its temperature. Air as moist as it can be is said to be *saturated*, and the amount of moisture required for saturation increases rapidly with the temperature. I may say, in a general way, that it doubles with each rise of 15° F. of temperature; that is, at 90° air will hold about twice as much moisture as at 75°, nearly four times as much as at 60°, and more than seven times as much as at 45°. Therefore, air moist to saturation at 60°, if heated to 75°, is then only half saturated, and seems dry; and if further heated to 80° or 90°, it then seems very dry indeed, although it contains as much water as air saturated at 60°. Hence, when warm air is moist, it contains very much moisture, and dry grains readily extract some from such air.

The accompanying table shows the relative weights of the several samples of grain in the moist air of late summer and the dry air of a furnace-heated office in winter. The table embraces forty samples in all (numbered for convenience of reference), representing several varieties of each of the grains, and from various parts of the country. They also represent various grades and qualities. For example, the wheats 1, 2, 3, 10, and 11 are very plump, and the sample No. 4 is very badly shrunken. Of the corns, No. 17 has grains eleven times as large as those of No. 12, and various other characters are represented. Twenty-two of the samples are from the lots that were analyzed, and the numbers are given in the second column of the table under which they occur in the tables of chemical composition. Columns 3 and 4 give the variety and place where grown.

The fifth column gives the year of the crop. It will be seen that all the specimens except two had been dried over one winter before the experiments began; some of the grains were three years old, and one specimen of corn four years old.

The sixth column shows the weight in early autumn of 1880. During the summer all the specimens had gained in weight, some of them nearly 6 per cent., others less, according to the way they had been kept the previous winter.

The seventh column represents the least weight in the dry air of winter, and all the other weights are calculated from this as a standard. They had lost about 6 per cent. since the previous summer.

The eighth column shows the weight in the late summer of 1881, when the specimens had gained from 6.8 to 8.4 per cent. It is somewhat remarkable that all the samples lost and gained so nearly alike when we consider the variety of the samples, but the uniformly large gain in the moist air of the seaport is very suggestive, and illustrates how grain dried in one climate may gain in another, or how it may lose and gain in the same climate where the air has access to the whole of the mass.

The ninth column shows the weight as dried in a desiccator from one hundred to one hundred and thirty days. The weight would be reduced by a longer exposure to this artificially dried air, for the specimens have continued to lose so long as the experiment has been going on, very slowly at last; yet the loss does go on, and illustrates the extreme tenacity with which the grain clings to some moisture. In fact, it continues to hold some, despite such drying, as is shown in the next column.

The tenth column shows the ultimate weight when dried in a vacuum at 230°, until there is no further loss in weight.

The experiments of Professor Hilgard, already cited, show the rapidity with which very dry grain absorbs moisture from an artificially saturated air the first few hours of exposure. I varied the experiment, and several specimens of wheat, dried in a desiccator for fifty-one days, until they weighed 6 or 7 per cent. less than the lowest air-dried weight in the tables, were then weighed in a tight metallic vessel, and then spread out on sheets of white paper on the sill of an open window, in free access of air, on a warm, muggy day, when the temperature was 77.2° and the wet-bulb 75°, and after a few minutes weighed again with the same precautions. One specimen of the wheat gained 0.19 (about one-fifth) of one per cent. in three minutes, another 0.35 per cent. in six minutes, another 1.64 in twenty-four minutes, and another 2.02 per cent. in fifty-four minutes. These illustrate strikingly the amount of absorption that may take place during even rapid handling, and the rapid change that sometimes occurs in hot, muggy climates. The converse is, of course, true, and based on it are the means of rapidly drying too moist grains by agitation in air dried by artificial heat.

TABLE XXIV.—LOSS AND GAIN IN WEIGHT OF GRAIN DUE TO SPONTANEOUS LOSS AND GAIN OF MOISTURE.

No.	Corresponding analysis number.	Grain.	Where grown.	Year of crop.	Weight, September, 1880.	Weight, February, 1881.	Weight, September, 1881.	Weight, dried in desiccator.	Weight, dried at 230° F.
		WHEAT.							
1		Little Club, winter	Oregon	1877	105.9	100	108.4	94.8	
2		White Club, winter	...do	1877	105.8	100	108.4		
3		Australian, winter	...do	1877	105.9	100	108.3	94.5	
4		Badly shrunken, winter	California	1880	107.3	100	107.7	94.8	
5		Somewhat shrunken, winter	...do	1880	107.4	100	108.2	92.7	
6		Milwaukee Club, winter	"Western"	1877	105.8	100	108.4	94.9	
7	57	Red Winter, No. 2	...do	1879	106.1	100	108.2	94.1	92.5
8	42	Red Winter	New York	1879	106.2	100	107.7	93.0	91.5
9	21	White Winter	...do	1879	106.2	100	108.3	93.9	92.3
10		Sonora Spring	Oregon	1877	105.8	100	107.9	94.9	91.6
11		White Australian, spring	...do	1877	105.9	100	108.0	94.5	
		CORN.							
12	145	An 8-rowed White pop-corn	Connecticut	1876	105.9	100	107.1	95.6	
13	178	Pop, Yellow and White mixed	New York	1879	106.0	100	107.2		
14	154	Waushakum	Massachusetts	1879	106.1	100	107.2		
15		Wisconsin Dent	Connecticut	1878	105.7	100	107.3		
16		Black Sweet	...do	1878	105.6	100	107.8		
17		Cuzco	Peru	1879	107.9	100	107.6		
		OATS.							
18		Potato (very heavy)	Oregon	1877	105.1	100	106.7		
19		Surprise (very heavy)	...do	1877	105.1	100	106.9		
20	284	Common (38 pounds per bushel)	Michigan	1879	105.7	100	107.7		
21		Common (34 pounds per bushel)	New York	1879	105.5	100	107.3		
22	275	Common	Connecticut	1879	105.4	100	107.1		
23	277	Common	...do	1879	105.6	100	107.3		
24	286	Common (32 pounds per bushel)	New Hampshire	1879	105.4	100	107.8		
		BARLEY.							
25		Oregon	Oregon	1877	105.2	100	107.2		
26	306	4-rowed	New York	1879	105.6	100	108.0		
27	307	2-rowed	...do	1879	105.8	100	107.6		
28	303	2-rowed	Massachusetts	1879	105.7	100	107.8		
29	304	Common	New Hampshire	1879	105.5	100	107.7		
30	308	4-rowed	Canada	1879	105.6	100	107.6		
		RYE.							
31	322	Common	New Hampshire	1879	105.9	100	108.2	94.6	
32		Common	North Carolina	1879	107.9	100	107.9		
33		Common	...do	1879	108.2	100	107.8		
		BUCKWHEAT.							
34	331	Silver Hull	Connecticut	1879	106.1	100	107.8		
35	333	Silver Hull	Massachusetts	1879	106.0	100	107.9		
36	334	Silver Hull	Minnesota	1879	105.8	100	107.9		
37	338	Silver-gray	New York	1879	106.3	100	108.2		
38	335	Silver-gray	New Hampshire	1879	106.1	100	107.9		
39	332	Common Gray	Connecticut	1879	106.0	100	107.2		
40		Common	North Carolina	1879	108.5	100	108.0		