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SECTION III.

PHYSIOGRAPHY.

§ 1. General Description of Australia.

1. **Geographical Position.**—The Australian Commonwealth includes Australia proper lying in the Southern Hemisphere, an island continent, and Tasmania, in all an area of about 2,974,581 square miles, the mainland alone containing about 2,948,366 square miles. Bounded on the west and east by the Indian and Pacific Oceans respectively, it lies between longitudes 113° 9′ E. and 153° 39′ E., while its northern and southern limits are the parallels of latitude 10° 41′ S. and 39° 8′ S., or including Tasmania, 43° 39′ S. On its north are the Timor and Arafura Seas and Torres Strait, on its south the Southern Ocean and Bass Strait.[1]

(i.) *Tropical and Temperate Regions.* Of the total area of Australia the lesser portion lies within the tropics. Assuming, as is usual, that the latitude of the Tropic of Capricorn is 23° 30′ S.[2], the areas within the tropical and temperate zones are approximately as follows :—

AREAS OF TROPICAL AND TEMPERATE REGIONS
OF STATES WITHIN TROPICS.

	Queensland.	Northern Territory.	Western Australia.	Total.
	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.
Within Tropical Zone	359,000	426,320	364,000	1,149,320
Within Temperate Zone	311,500	97,300	611,920	1,020,720
Ratio of Tropical part to whole State ...	0.535	0.814	0.373	0.530
Ratio of Temperate part to whole State ...	0.465	0.186	0.627	0.470

Thus the tropical part is roughly about one half (0.530) of the three territories mentioned above, or about five-thirteenths of the whole Commonwealth (0.386). See hereafter Meteorology 1.

2. **Area of Australia compared with that of other Countries.**—That the area of Australia is greater than that of the United States of America, that it is four-fifths of that of Canada, that it is more than one-fourth of the area of the whole of the British Empire, that it is nearly three-fourths of the whole area of Europe; that it is about 25 times as large as any one of the following, viz., the United Kingdom, Hungary, Norway, Italy, the Transvaal, and Ecuador, are facts which are not always adequately realised. It is this great size, taken together with the fact of the limited population, that gives to the problems of Australian development their unique character, and its clear comprehension is essential in any attempt to understand those problems.

1. The extreme points are "Steep Point" on the west, "Cape Byron" on the east, "Cape York" on the north, "Wilson's Promontory" on the south, or, if Tasmania be included, "South East Cape." The limits, according to the 1903-4 edition of "A Statistical Account of Australia and New Zealand," p. 2; and, according to Volume XXV. of the "Encyclopædia Britannica," p. 787; are respectively 113° 5′ E., 153° 16′ E., 10° 39′ S., and 39° 11½′ S., but these figures are obviously defective.

2. Its correct value for 1908.0 is 23° 27′ 4″.5.

The relative magnitudes may be appreciated by a reference to the following table, which shews how large Australia is compared with the countries referred to, or *vice versa*. Thus, to take line 1, we see that Europe is about $1\frac{3}{10}$ times (1.29776) as large as Australia, or that Australia is about three-quarters (more accurately 0.78) of the area of Europe.

SIZE OF AUSTRALIA

IN COMPARISON WITH THAT OF OTHER COUNTRIES.

Commonwealth of Australia ... 2,974,581 square miles.

Country.	Area.	Australian Commonw'lth in comparison with—	In comparison with Australian C'wealth.
Continents—	sq. miles.		
Europe	3,860,303	0.78	1.29776
Asia	16,959,481	0.18	5.70147
Africa	11,405,803	0.26	3.83442
North and Central America and West Indies ...	8,549,509	0.35	2.87419
South America	7,310,914	0.41	2.46788
Australasia and Polynesia	3,455,399	0.86	1.16164
Total, exclusive of Arctic and Antarctic Conts.	51,571,409	0.06	17.33736
Europe—			
Russia (inclusive of Poland, Ciscaucasia & Finland)	2,122,527	1.40	0.71355
Austria-Hungary (incl. of Bosnia & Herzegovina)	261,035	11.39	0.08776
Germany	208,780	14.25	0.07011
France	207,054	14.37	0.06969
Spain	194,770	15.27	0.06548
Sweden	172,876	17.21	0.05812
Norway	124,130	23.96	0.04173
United Kingdom	121,390	24.50	0.04081
Italy	110,659	26.88	0.03720
Turkey (inclusive of Bulgaria and Crete) ...	106,830	27.85	0.03591
Denmark (inclusive of Iceland)	55,348	53.73	0.01861
Rumania	50,720	58.65	0.01705
Portugal	35,490	83.82	0.01193
Greece	25,014	118.91	0.00841
Servia	18,650	159.49	0.00627
Switzerland	15,976	186.22	0.00537
Netherlands	12,648	235.29	0.00425
Belgium	11,373	261.78	0.00382
Montenegro	3,630	819.67	0.00122
Luxemburg	998	2941.18	0.00034
Andorra	175	16997.61	0.00006
Malta	117	25423.76	0.00004
Liechtenstein	65	45793.55	0.00002
San Marino	38	78278.45	0.00001
Monaco	8	371822.63	...
Gibraltar	2	1487290.50	...
Total, Europe	3,860,303	0.78	1.29776
Asia—			
Russia (inclusive of Transcausia, Siberia, Steppes, Transcaspia, Turkestan and inland waters) ...	6,525,130	0.45	2.19364
China and Dependencies...	4,277,170	0.70	1.43791
British India...	1,087,124	2.74	0.36547
Independent Arabia	966,700	3.08	0.32499
Turkey (including Samos)	693,790	4.29	0.23324
Feudatory Indian States...	679,393	4.38	0.22840
Persia	628,000	4.74	0.21112

Country.	Area.	Australian Commonwe'lth in comparison with—	In comparison with Australian C'wealth.
ASIA (continued)—			
Dutch East Indies	584,611	5.09	0.19654
Afghanistan	250,000	11.90	0.08405
Siam	212,200	14.02	0.07134
Japan (inclusive of Formosa, Pescadores, and Southern Sakhalin)	190,534	15.61	0.06405
Philippine Islands (inclusive of Sulu Archipelago)	127,853	23.27	0.04298
Laos	98,400	30.23	0.03308
Omán	82,000	36.27	0.02757
Bokhara	80,000	37.19	0.02689
British Borneo and Sarawak	73,100	40.70	0.02457
Korea	71,000	41.89	0.02387
Nepál	54,000	55.10	0.01815
Annam	52,100	57.08	0.01752
Tonking	46,000	64.68	0.01546
Cambodia	37,400	79.55	0.01257
Federated Malay States	26,380	112.74	0.00887
Ceylon	25,330	117.37	0.00852
Khiva	22,320	133.33	0.00750
Cochin China...	20,000	148.81	0.00672
Bhután	16,800	176.99	0.00565
Aden and Dependencies	9,080	327.87	0.00305
French Siam	7,800	381.68	0.00262
Timor, etc.	7,330	406.50	0.00246
Cyprus	3,580	833.33	0.00120
Goa, Damaõ, and Diu	1,638	1818.18	0.00055
Straits Settlements	1,600	1851.85	0.00054
Hong Kong and Dependencies	390	7692.31	0.00013
Wei-hai-wai	280	10623.50	0.00009
Kiauchau	200	14872.91	0.00007
French India (Pondicherry, etc.)	196	15176.43	0.00007
Labuan	30	99152.70	0.00001
Italian Concession, Tientsin	18	165254.50	0.00001
Macao, etc.	4	743643.25	...
Total, Asia	16,959,481	0.18	5.70147
Africa—			
French Sahara	1,944,000	1.53	0.65354
Turkey (inclusive of Egypt and Soudan) ...	1,748,900	1.70	0.58795
Congo Independent State	900,000	3.31	0.30256
French Congo	850,000	3.50	0.28575
Angola	484,800	6.14	0.16298
Rhodesia	435,000	6.83	0.14633
German East Africa	384,180	7.74	0.12915
Senegambia and Niger	370,000	8.04	0.12439
Algeria	343,500	8.66	0.11548
German South-west Africa	322,450	9.23	0.10840
Portuguese East Africa	293,400	10.14	0.09864
Cape Colony	276,990	10.74	0.09312
Bechuanaland Protectorate	275,000	10.82	0.09245
Northern Nigeria Protectorate	256,400	11.60	0.08620
Madagascar and adjacent Islands	228,000	13.05	0.07665
Uganda Protectorate	223,500	13.31	0.07514
Morocco	219,000	13.58	0.07362
Abyssinia	200,000	14.87	0.06724
Kamerun	191,130	15.56	0.06425
British East Africa Protectorate	175,590	16.94	0.05903
Ivory Coast	120,000	24.79	0.04034
Gold Coast Protectorate	119,260	24.94	0.04009

Country.	Area.	Australian Commonwe'lth in comparison with—	In comparison with Australian C'wealth.
AFRICA (continued)—			
Transvaal	117,730	25.27	0.03958
Italian Somaliland	100,000	29.74	0.03362
French Guinea	95,000	31.31	0.03194
Eritrea	88,500	33.61	0.02975
Southern Nigeria and Protectorate	77,260	38.51	0.02597
Rio de Oro, etc.	70,000	42.50	0.02353
British Somaliland	68,000	43.74	0.02286
Dahomey	65,000	45.77	0.02185
Tunis	64,600	46.04	0.02172
Orange River Colony	50,390	59.03	0.01694
Liberia	43,000	69.16	0.01446
Nyasaland Protectorate	40,980	72.57	0.01378
Natal	35,370	84.10	0.01189
Togoland	33,700	88.26	0.01133
Sierra Leone and Protectorate	30,000	99.11	0.01009
Portuguese Guinea	13,940	213.22	0.00469
French Somali Coast, etc.	12,000	248.14	0.00403
Basutoland	10,290	289.02	0.00346
Rio Muni, etc.	9,800	303.95	0.00329
French Senegal	9,070	327.87	0.00305
Gambia Protectorate	3,620	819.67	0.00122
Cape Verde Islands	1,480	2000.00	0.00050
Zanzibar	1,020	2941.18	0.00034
Réunion	970	3030.30	0.00033
Mauritius and Dependencies	840	3571.43	0.00028
Fernando Po, etc.	780	3846.15	0.00026
Comoro Islands	620	4761.91	0.00021
St. Thomas and Prince Islands	360	8262.73	0.00012
Seychelles	150	19830.54	0.00005
Mayotte, etc.	140	21247.01	0.00005
St. Helena	46	64664.80	0.00002
Ascension	34	87487.68	0.00001
Spanish North and West Africa	13	228813.92	...
Total, Africa	11,405,803	0.26	3.83452
North and Central America and West Indies—			
Canada	3,745,570	0.79	1.25919
United States	2,970,230	1.00	0.99854
Mexico	767,005	3.88	0.25785
Alaska	590,884	5.03	0.19864
Newfoundland and Labrador	162,730	18.28	0.05471
Nicaragua	49,200	60.46	0.01654
Guatemala	48,290	61.61	0.01623
Greenland	46,740	63.65	0.01571
Honduras	46,250	64.31	0.01555
Cuba	44,000	67.61	0.01479
Costa Rica	18,400	161.55	0.00619
San Domingo	18,045	164.74	0.00607
Haiti	10,204	291.55	0.00343
British Honduras	7,560	393.70	0.00254
Salvador	7,225	411.52	0.00243
Bahamas	4,400	675.68	0.00148
Jamaica	4,210	704.23	0.00142
Porto Rico	3,435	869.57	0.00115
Trinidad and Tobago	1,870	1587.30	0.00063
Leeward Islands	700	4166.67	0.00024
Guadeloupe	688	4323.52	0.00023
Windward Islands	670	4439.67	0.00023

Country.	Area.	Australian Commonwe'lth in comparison with—	In comparison with Australian C'wealth.
N. & C. AMERICA & W. INDIES (continued)—			
Curaçao and Dependencies	403	7381.09	0.00014
Martinique	380	7827.84	0.00013
Turks and Caicos Islands	170	17497.54	0.00006
Danish West Indies	138	21554.94	0.00005
St. Pierre and Miquelon	92	32332.40	0.00003
Bermudas	20	148729.05	0.00001
Total, N. and C. America and W. Indies...	8,549,509	0.35	2.87421
South America—			
Brazil (inclusive of Acré)...	3,292,991	0.90	1.10704
Argentine Republic	1,135,840	2.62	0.38185
Peru	695,733	4.28	0.23389
Bolivia	605,400	4.91	0.20352
Colombia	444,980	6.68	0.14959
Venezuela	364,000	8.17	0.12237
Chile	307,620	9.67	0.10342
Ecuador	116,000	25.64	0.03900
Paraguay	98,000	30.35	0.03295
British Guiana	90,280	32.95	0.03035
Uruguay	72,210	41.19	0.02428
Dutch Guiana	46,060	64.60	0.01548
Panamá	33,800	88.03	0.01136
French Guiana	30,500	97.56	0.01025
Falkland Islands	6,500	456.62	0.00219
South Georgia	1,000	2974.58	0.00034
Total, South America	7,340,914	0.41	2.46788
Australasia and Polynesia—			
Commonwealth of Australia	2,974,581	1.00	1.00000
Dutch New Guinea	151,789	19.60	0.05103
New Zealand and Dependencies	104,751	28.39	0.03522
Papua	90,540	32.85	0.03044
German New Guinea	70,000	42.50	0.02353
Bismarck Archipelago	20,000	148,73	0.00672
British Solomon Islands	8,360	355.87	0.00281
Fiji	7,740	384.62	0.00260
New Caledonia and Dependencies	7,650	389.11	0.00257
Hawaii	6,449	460.83	0.00217
New Hebrides	5,000	594.92	0.00168
German Solomon Islands	4,200	709.22	0.00141
French Establishments in Oceania	1,520	1960.78	0.00051
German Samoa	1,000	2974.58	0.00034
Caroline and Pelew Islands	560	5311.75	0.00019
Tonga	390	7627.13	0.00013
Marianne Islands	250	11898.32	0.00008
Guam	200	14872.91	0.00007
Gilbert Islands	180	16525.45	0.00006
Marshall Islands	150	19830.54	0.00005
Samoa (U.S.A. part)	79	37652.92	0.00003
Norfolk Island	10	297458.10	...
Total, Australasia and Polynesia ...	3,455,399	0.86	1.16164
British Empire...	11,437,496	0.26	3.84508

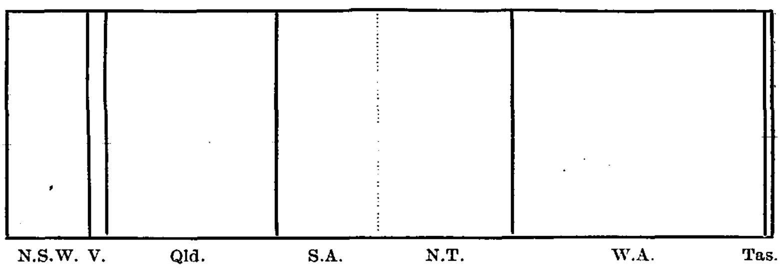
3. **Relative Size of Political Subdivisions.**—As already stated, Australia is divided into six States, the areas of which, in relation to one another and to the total of Australia, are shewn in the following table :—

RELATIVE SIZES OF STATES AND COMMONWEALTH.

State.	Area.	Ratio which the Area of each State bears to that of other States and Commonwealth.						
		N.S.W.	Victoria.	Q'land.	S.A. (Total.)	W. Aust.	Tas.	C'wlth.
	Sq. miles.							
N.S.W. ...	310,372	1.000	3.532	0.463	0.344	0.318	11.840	0.104
Victoria ...	87,884	0.283	1.000	0.131	0.097	0.090	3.352	0.030
Queensland	670,500	2.160	7.629	1.000	0.742	0.687	25.577	0.225
S.A. (total)	903,690	2.912	10.283	1.348	1.000	0.926	34.472	0.304
S.A. (proper)	(380,070)	(1.225)	(4.325)	(0.567)	(0.421)	(0.389)	(14.498)	(0.128)
N. Terr. ...	(523,620)	(1.687)	(5.958)	(0.781)	(0.579)	(0.537)	(19.974)	(0.176)
W. Aust. ...	975,920	3.144	11.105	1.455	1.080	1.000	37.228	0.328
Tasmania ...	26,215	0.085	0.298	0.039	0.029	0.027	1.000	0.009
Total ...	2,974,581	9.584	33.847	4.436	3.292	3.048	113.469	1.000

Thus, looking at the top line, New South Wales is seen to be over three-and-a-half times as large as Victoria (3.532) and less than one-half the size of Queensland (0.463): or again, looking at the bottom line, the Commonwealth is shewn to be more than nine-and-a-half times as large as New South Wales (9.584), and nearly thirty-four times as large as Victoria (33.847).

These relative magnitudes are shewn in the small diagram below. It may be added that Papua (or British New Guinea), with its area of 90,540 square miles, is 0.030 of the area of the Commonwealth.



4. **Coastal Configuration.**—There are no striking features in the configuration of the coast: the most remarkable indentations are the Gulf of Carpentaria on the north and the Great Australian Bight on the south. The York Peninsula on the extreme north is the only other remarkable feature in the outline. In Year Book No. 1 an enumeration of the features of the coast-line of Australia is given on pp. 60 to 68. This is not here repeated.

(i.) *Coast-line.* The lengths of coast-line, exclusive of minor indentations, both of each State and of the whole continent, are shewn in the following table :—

SQUARE MILES OF TERRITORY PER MILE OF COAST-LINE.

State.	Coast-line.	Area ÷ Coast-line	State.	Coast-line.	Area ÷ Coast-line.
	Miles.	Sq. miles.		Miles.	Sq. miles.
New South Wales...	700	443	South Australia ...	1,540	247
Victoria	680	129	Western Australia	4,350	224
Queensland ...	3,000	223	Continent[1] ...	11,310	261
Northern Territory	1,040	503	Tasmania ...	900	29

1. Area 2,948,366 square miles.

For the entire Commonwealth this gives a coast-line of 12,210 miles, and an average of 244 square miles for one mile of coast-line. According to Strelbitski, Europe has only 75 square miles of area to each mile of coast-line, and, according to recent figures, England and Wales have only one-third of this, viz., 25 square miles.

(ii.) *Historical Significance of Coastal Names.* It is interesting to trace the voyages of some of the early navigators by the names bestowed by them on various coastal features—thus Dutch names are found on various points of the Western Australian coast, in Nuyts' Archipelago, in the Northern Territory, and in the Gulf of Carpentaria; Captain Cook can be followed along the coasts of New South Wales and Queensland; Flinders' track is easily recognisable from Sydney southwards, as far as Cape Catastrophe, by the numerous Lincolnshire names bestowed by him; and the French navigators of the end of the eighteenth and the beginning of the nineteenth century have left their names all along the Western Australian, South Australian, and Tasmanian coasts.

5. **Hydrology of Australia.**—It is not the function of this Year Book to furnish in any one number a complete geographical account of Australia, but, as previously indicated (Year Book No. 1), it is intended each year to give the most complete available information concerning some special geographical element. In this number an enumeration of the rivers and their approximate lengths is selected.

On the whole, Australia is a country with a limited rainfall. This is immediately evident on studying its river systems, its lakes, and its artesian areas. Its one large river system is that of the Murray and Darling Rivers, of which the former stream is the larger and more important. Many of the rivers of the interior run only after heavy rains. Depending almost entirely on rainfall, a consequence of the absence of high mountains, they drain large areas with very varying relation as between rainfall and flow. Thus it has been estimated that not more than 10 per cent. of the rainfall on the "catchment-area" of the Darling River above Bourke (N.S.W.) discharges itself past that town. The rate of fall is often very slight.

(i.) *Rivers.* The rivers of Australia may be divided into two great classes, those of the coastal plains, with moderate rates of fall, and those of the central plains, with very slight fall. Of the former not many are navigable for any distance from their mouths, and some are difficult of access or inaccessible from the sea on account of bars.

The two longest rivers of the northern part of the eastern coast are the Burdekin, discharging into Upstart Bay, with a catchment area of 53,500 square miles; and the Fitzroy, which reaches the sea at Keppel Bay, and drains about 55,600 square miles. The Hunter is the largest coastal river of New South Wales, draining about 11,000 square miles, before it empties itself at Newcastle. The Murray River, with its great tributary, the Darling, drains a considerable part of Queensland, the major part of New South Wales, and a large part of Victoria. It debouches into the arm of the sea known as Lake Alexandrina, on the eastern side of the South Australian coast. The total length of the Murray is about 1600 miles, 400 being in South Australia, and 1200 constituting the boundary between New South Wales and Victoria.[1]

The total length of the Darling-Murray from the source of the Darling to the mouth of the Murray is 2310 miles.[1]

The rivers on the north-west coast of Australia (Western Australia) are of considerable size, *e.g.*, the Murchison, Gascoyne, Ashburton, Fortescue, DeGrey, Fitzroy, Drysdale, and Ord. So also are those in the Northern Territory, *e.g.*, Victoria and Daly. The former of these, estimated to drain 90,000 square miles, is said to be navigable by the largest vessels for 50 miles.

The rivers on the Queensland side of the Gulf of Carpentaria are also of considerable size, *e.g.*, Gregory, Leichhardt, Cloncurry, Gilbert, Mitchell, etc.

Owing to the small fall of many of the interior rivers, in wet seasons they may flood hundreds of miles of country, while in dry seasons they form a mere succession of water-

1. These distances were differently given in Year Book No. 1, but have since been measured on large scale maps, with the results as shewn.

holes, or are entirely dry. It is this fact that explains the apparently conflicting reports of the early explorers, one regarding the interior as an inland sea, and another as a desert.

The rivers of Tasmania have short and rapid courses, as the configuration of the territory indicates.

The following table[1] gives a list of the principal rivers in each State together with their approximate lengths, and shews moreover the tributary systems and the lengths of the tributaries :—

A comparison of the different sources of official information as to the lengths of the rivers of the Commonwealth shewed considerable discrepancies, even in important and well-known rivers. These discrepancies were relatively so large that it seemed desirable to re-estimate the lengths by using the largest scale maps available, and following all the bends of the rivers. This was carefully done for all the States by two methods—the mean of the two results, differing very slightly, being taken.

In the case of Queensland, South Australia, and Tasmania, the Lands Departments of those States were good enough to supply the lengths: where these substantially agreed with those computed as indicated, the lengths furnished were adopted. In the very few cases where the discrepancy was large, the result computed in the Bureau was retained in preference.

For purposes of reference, the following table has been prepared shewing the magnitude of the discrepancy :—

COMPARISON OF PUBLISHED LENGTHS OF VARIOUS RIVERS IN THE COMMONWEALTH.

River.	C'wealth Official Year Book, No. 2.	Statistical Account of Aust. & N.Z., 1903-4. (Coghlan.)	Notes on the Colony of Victoria, 1875. (Hayter.)	Victorian Year Book, 1906-7. (Drake.)
	Miles.	Miles.	Miles.	Miles.
Murray (between Vict. & N.S.W.)	1,200	1,250	670	980
Murray (total length) ...	1,600	1,719	...	1,300
Clarence	190	240	...	...
Macleay	160	200	...	...
Manning	150	100	...	...
Hunter	340	over 200	...	...
Hawkesbury	335	over 330	...	...
Shoalhaven	220	260	...	...
Murrumbidgee	1,050	1,350	...	...
Lachlan	850	700	...	...
Snowy (in New South Wales) ...	170	180	...	...
Snowy (in Victoria)	95	120	85	...
Mitta Mitta	125	175	90	175
Ovens	110	140	100	140
Goulburn	280	345	230	345
Campaspe	100	150	85	150
Loddon	155	225	150	225
Avoca	140	163	130	163
Wimmera	155	228	135	228
Yarra Yarra	115	150	90	150
Hopkins	135	155	110	155
Glenelg	280	280	205	281
Barwon	75	...	70	95
Werribee	60	...	55	70
Saltwater	65	...	70	170
La Trobe	70	...	90	140
Macalister	110	...	65	115
Thompson	60	...	...	100
Mitchell	60	...	60	80
Tambo	90	...	85	120

1. The information is given in much greater detail than is possible on any but the largest maps, and is, therefore, not generally available. The series of Year Books will thus furnish detailed information of the several geographical features of Australia.

APPROXIMATE LENGTHS OF PRINCIPAL RIVERS OF THE COMMONWEALTH.

R. signifies tributary on right bank, and L. on left bank.

5A. **New South Wales.**—Starting at the south-western extremity and going easterly, northerly, and westerly.

	MILES
Murray River (total length between New South Wales and Victoria)	1,200
R. Anabranch of Darling	320
R. Darling River (joins Murray 150 miles from S.A. border)	1,760
L. Talyawalka (Anabranch)	260
R. Warrego River (joins Darling 950 miles from mouth), N.S.W. portion	130
R. Irrara Creek	60
R. Culgoa River (joins Darling 1070 miles from mouth), N.S.W. portion	130
L. Birrie River	110
L. Bogan River (joins Darling 1075 miles from mouth)	370
R. Duck River	70
R. Gunningbar Creek	70
L. Bulbodney Creek	60
R. Bokhara River	160
L. Marra Creek	180
L. Crooked Creek	100
L. Macquarie River (joins Darling 1260 miles from mouth)	590
R. Castlereagh River	340
L. Nedgera Creek	80
L. Mowlma Creek	50
R. Marthagay Creek	200
R. Merri Merri Creek	90
R. The Big Warrambool River	100
L. Namoi River (joins Darling 1360 miles from mouth)	430
R. Pian Creek	120
L. Baradine Creek	110
L. Dubbo Creek	50
L Peel River	50
L. Thalaba Creek	90
L. Meei or Gywdir River (joins Darling 1460 miles from mouth)	350
L. Moomin Creek	110
L. Boomi River	110
L. Gil Gil Creek	130
L. Whalan Creek	110
L. Croppa Creek	70
L. Macintyre River (to junction of Dumaresq River)	180
R. Severn River	120
R. Murrumbidgee River (joins Murray 430 miles from S.A. border)	1,050
R. Lachlan River (joins Murrumbidgee 130 miles from mouth)	850
R. Marrowie Creek	100
R. Willandra Billabong Creek	250
L. Euglo Creek	120
R. Goobang Creek	140
R. Mandagery Creek	80
L. Boorowa River	80
R. Abercrombie River	110
R. Crookwell River	35
L. Old Man Creek	40
L. Bullenbung Creek	40
R. Houlaghan's Creek	50
L. Yaven Yaven Creek	40
R. Billabong Creek	35
L. Adelong Creek	35
L. Tumut River	90
——Murrumbidgee River (continued)	
L. Goodradigbee River	60
R. Molonglo River	90
R. Umaralla Creek	90
R. Kyalite Edward River	280
L. Wakool River	240
R. Yarrien Creek	100
R. Niemur River	90
L. Merran Creek	60
R. Moulamein or Billabong Creek	400
R. Yanko Creek	190
R. Tuppal Creek	60
R. Swampy Plain River	40
Snowy River (upper portion called Eucambene River), N.S.W. portion	170
R. Mumbla Creek	30
L. Delegete Creek	60
L. McLaughlin River	60
L. Bobundara Creek	35
R. Wullwye Creek	30
Wallagaraugh River	30
Towamba River	50
Bega or Bemboka River	55
L. Brogo River	35
Tuross River	70
Clyde River	80
Shoalhaven River	220
R. Mongarlowe River	40
Hawkesbury River	335
L. Colo River	60
R. Capertee River	60
R. Nepean River	45
R. Nattai River	35
R. Cox's River	80
Hunter River	340
L. Williams River	100
L. Paterson River	100
R. Goulburn River	140
L. Wybung Creek	50
L. Kria Creek	50
R. Dart Brook	40
R. Isis River	70
Karuah River	50
Myall River	30
Wollomba River	45
Manning River	150
L. Dingo Creek	40
R. Barrington River	75
L. Nowendoc River	65
L. Barnard River	90
Hastings River	110
L. Maria River	30
R. Ellenborough River	30
Macleay River	160
R. Apsley River	90
L. Chandler River	55
Bellinger River	60
Clarence River	190
R. Orara River	80
R. Nymboida River	110
L. Mann River	90
R. Timbara River	95
Richmond River	160
Tweed River	40
Narran River (N.S.W. portion)	100
Paroo River (N.S.W. portion)	103

5B. **Victoria.**—Starting at the north-eastern extremity and going westerly, southerly, and easterly.

Murray River (total length between New South Wales and Victoria)	1,200
L. Corryong Creek	45
L. Cudgewa Creek	50
L. Cooyatong Creek	20
L. Mitta Mitta River	125
R. Tallangatta Creek	30
L. Little Snowy Creek	20
L. Snowy Creek	25
——Mitta Mitta River (continued)	
R. Gibbo Creek	20
L. Wombat Creek	20
L. Bundarrah Creek	30
L. Kiewa River	70
R. Big River	40
L. Indigo Creek	25
L. Doma Mungi River	40
L. Ovens River	110

	MILES
—Ovens River (continued)	
L. King River ...	75
R. Hodgson's Creek	20
L. Whorouly Creek	25
L. Buffalo River ...	50
R. Myrtle Creek ...	20
L. Buckland River	30
L. Tullah Creek	20
L. Broken Creek	125
R. Black Creek	50
L. Tsheeca Creek	20
L. Goulburn River	280
R. Broken River ...	105
R. Stony Creek	40
L. Seven Creeks	50
R. Castle Creek	40
R. Muddy Creek ...	20
R. Hughes Creek ...	40
L. Sugarloaf Creek	20
L. Dabyminga Creek	25
L. Yea River	35
L. Acheron River	30
R. Delatite River ...	55
L. Big River	20
R. Howqua River	40
R. Jamieson River	25
L. Campaspe River	100
R. Mt. Pleasant Creek	20
L. Coliban River ...	45
L. Loddon River	155
R. Muirabit River	25
R. Pyramid Creek	95
L. Bullabul Creek	25
R. Bradford Creek	20
L. Bet Bet Creek ...	40
Avoca River	140
L. Cherry Tree Creek	20
Tyrrell Creek	85
Avon River	75
L. Richardson River ...	30
Yarriambiack Creek	80
Wimmera River ...	155
L. Norton Creek	30
L. Mackenzie River ...	45
L. Concongella Creek	25
Glenelg River	280
L. Crawford River	40
L. Stokes River	30
L. Wannon River	150
L. Chetwynd River	25
L. Mather's Creek	20
Surry River	25
Fitzroy River	25
L. Darlot's Creek	25
Eumeralla River ...	70

	MILES
Shaw River	25
Moyne River	40
Merri River	30
L. Drysdale Creek	20
Hopkins River	135
L. Mount Emu Creek	170
L. Salt Creek ...	25
R. Gray's Creek	20
R. Bushy Creek	20
Fiery Creek	75
Curdie's Creek	55
Gellibrand River ...	65
Thomson's Creek ...	20
Barwon River	75
L. Moorabool River ...	35
L. Yarrawee River	50
L. Warrambune Creek	60
Little River	30
Werribee River	60
L. Lerderderg River ...	25
Yarra Yarra River	115
R. Saltwater River	65
R. Plenty River	30
L. Dandenong Creek ...	30
R. Watts River	20
Bass River	35
Powlett River	30
Bruthen Creek	20
Merriman's Creek	55
La Trobe River	70
L. Thompson River ...	60
L. Macalister River	110
Avon River	50
Perry River	35
Tom's River	20
Mitchell River	60
L. Wentworth River ...	55
L. Dargo River	75
L. Wonnangatta River	85
L. Wongungarra River	35
Nicholson River ...	45
Tambo River	90
L. Little River	20
Boggy Creek	30
Snowy River (Victorian portion) ...	95
R. Murrindal River ...	30
L. Broadbent Creek ...	20
L. Mountain Creek	20
L. Jingallala River	35
R. Toonginbooka River	30
Bemm River	20
Cann River	25
Thurra River	20
Genoa River	50

5C. **Queensland.**—Starting at the north-western extremity and going easterly, northerly, southerly, and westerly.

Settlement Creek	50
Lagoon Creek	100
Cliffdale Creek	100
Nicholson River ...	130
R. Gregory River	160
R. Dariel Creek ...	16
R. Goonooma Creek	32
L. Ixion Creek	20
L. Verdon Creek ...	20
R. O'Shanassy River	80
R. Morstone Creek	14
L. Youl Creek	8
R. Harris Creek	30
R. Thornton River	40
L. Thornton Creek	34
L. Magenta Creek	34
R. Seymour River	45
R. Victor Creek	10
R. Police Creek ...	32
L. Macadam Creek	20
R. Tozer Creek	8
L. Lawn Hill Creek	112
L. Elizabeth Creek	72
Albert River	40
L. Beames Creek	48
R. Barclay River	35
R. Twelve Mile Creek	36
R. Saltwater Arm	6
R. Millar Creek	52

Albert River (continued)	
R. Landsborough Inlet	12
Leichhardt River ...	300
R. Gorge Creek	20
R Charley Creek	24
L. Paroo Creek	32
L. Surprise Creek	28
R. Prospector Creek	29
R. Cabbage Tree Creek	32
L. Coppermine Creek	26
L. St. Paul Creek	24
L. Eureka Creek	16
L. Mistake Creek	56
L. Gunpowder Creek ...	96
L. Myally Creek	45
L. Sandy Creek	52
R. Mittigoody Creek	24
L. Fiery Creek	88
R. Alexandra River	110
R. Lagoon Creek	30
Disaster Inlet	25
Morning Inlet	22
R. M. Creek	25
L. Punchbowl Creek ...	18
Flinders River	520
L. White Mountain Creek	12
R. Galah or Porcupine Creek	80
R. Canterbury Creek...	16
R. Betts Gorge Creek...	44

	MILES
Flinders River (continued)	
R. Stewart's Creek	30
L. Walker Creek	64
L. Eastern Creek	35
R. Dutton River	100
R. Chasm Creek	22
R. Pine Tree Creek	28
L. Station Creek	12
R. Camulla Creek	14
R. Deepwater Creek	10
R. Spinifex Creek	14
R. Yanko Creek	28
R. Tunis Creek	18
R. Alexander Creek	36
R. Hazlewood Creek	34
R. Stawell River	150
R. McDougall Creek	26
R. Rokehurst Creek	24
L. Poison Creek	16
R. Loth Creek	25
R. Woolgar River	60
L. Patience Creek	24
L. Hampstead Creek	26
L. Cecil Creek	16
L. Alick Creek	124
L. Rupert Creek	57
L. Cloncurry River	280
L Maggie Creek	16
R. Farley Creek	12
R. Gorge Creek	8
L. Sandy Creek	16
L. Spring Creek	30
R. Florence Creek	26
L. Cattle Creek	18
L. Malbon River	45
L. Limestone Creek	10
L. Duck Creek	22
R. Martin Creek	20
L. Slaty Creek	18
R. Snake Creek	20
L. Chinaman Creek	16
L. Table Creek	20
R. Gipsy Creek	24
R. Williams River	100
L. Roberts Creek	6
L. Elder Creek	22
L. Canal Creek	21
L. Eliza Creek	14
L. Mount Margaret Creek	20
R. Eastern Creek	120
L. Sadowa Creek	64
L. Gilliat River	110
R. Wild Duck Creek	34
L. McKinlay River	90
L. Dingding Creek	10
R. Rangeview Creek	18
L. Boorama Creek	32
R. Martin Creek	20
L. Nora Creek	46
L. Holy Joe Creek	44
L. Fullarton River	80
L. Dugald River	120
R. Middle Creek	62
R. Corella River	130
L. Cameron River	25
R. Malakoff Creek	20
R. Tommy Creek	38
L. Topsy Creek	12
L. Dismal Creek	80
R. Branch Creek	36
R. Saxby River	220
L. Express Creek	56
R. Mill Mill Creek	42
L. Cockatoo Creek	25
L. Wondoola Creek	26
L. Armstrong Creek	32
Bynoe River	40
Norman River	260
L. Spear Creek	86
R. Clara River	145
R. Yappar River	135
L. Brown Creek	58
R. Clarina Creek	57
R. Macrossan River	25
R. Carron River	100
R. Walker Creek	87
Brannigan Creek	20
Accident Inlet	10

	MILES
Accident Inlet (continued)	
R. Crooked Creek	22
L. Fitzmaurice Creek	30
Smithburne River	40
Van Diemen River	25
Gilbert River	312
R. Styx River	10
R. Granite Creek	18
L. Mica Schist Creek	15
L. Conglomerate Creek	12
R. Percy River	24
R. Robertson River	76
L. Left branch Robertson River	10
L. Oaky Creek	17
L. Little Robertson River	20
L. Agate Creek	24
R. Townley Creek	12
R. Western Creek	10
R. Crooked Creek	5
L. Langdon River	35
L. B Creek	6
R. Black Gin Creek	12
L. Little River	32
R. Einasleigh River	260
R. Bundock Creek	18
R. Lee Creek	40
R. Lagoon Creek	24
L. Copperfield River	100
R. Crooked Creek	5
L. Dumbano Creek	10
R. Middle Creek	12
L. Christmas Hill Creek	12
R. East Creek	15
L. Oak River	10
L. McMillan Creek	9
R. Junction Creek	45
R. Elizabeth Creek	60
R. Parallel Creek	33
L. Cattle Creek	24
L. Silent Creek	23
L. Etheridge River	96
L. Delaney River	25
L. Sandy Creek	25
R. Middle Creek	60
Vanrook Creek	95
Macaroni Creek	53
Staaten River	170
R. Cockburn Creek	50
L. Pandanus Creek	70
L. Emu Creek	62
R. Maramie Creek	48
R. Bloodwood Creek	36
L. Pelican Creek	60
Nassau River	85
R. Dunbar Creek	12
R. Scrutton River	45
L. Rocky Creek	19
Magnificent Creek	42
Mitchell River	350
R. Big Mitchell Creek	5
R. Little Mitchell Creek	6
L. Granite Creek	6
L. Dora Creek	4
L. Black Gin Creek	6
R. Rifle Creek	30
R. Station Creek	6
R. Mary Creek	7
R. McLeod River	18
R. Spencer Creek	8
R. Campbell Creek	8
R. Desailly Creek	4
L. Lizzie Creek	8
L. Wolstencroft Creek	7
L. Hodgkinson River	54
R. Columbia Creek	3
R. Explorer Creek	2
L. Spring Creek	2
R. Caledonia Creek	9
R. Deep Creek	2
L. Little River	8
L. Mt. Mulligan Creek	5
R. Eastern Hodgkinson	15
L. Little Watson Creek	14
R. St. George River	60
R. Right-hand branch St. George R.	18
R. Limestone Creek	12
L. Dry Creek	20
R. Little Mitchell River	20

	MILES
Mitchell River (continued)	
R. Sandy Creek	16
R. Rocky Creek	8
L. Walsh River	180
L. Emu Creek	40
L. Brown Creek	54
L. Lynd River	170
L. Mero Creek	15
L. Fossil Brook Creek	25
R. Pinnacle Creek	26
R. Tate River	80
R. California Creek	20
L. Rocky Tate River	30
R. Palmer River	190
R. Little Palmer River	13
L. Right-hand branch Palmer R.	15
R. Left-hand branch Palmer River	32
L. Sandy Creek	34
R. King Creek	24
R. Alice River	70
Coleman River	140
Edward River	60
Holroyd River	16
Lukin River	140
Kendal River	70
Archer River	170
L. Croll Creek	20
L. Bourne Creek	18
R. Irvine Creek	16
R. Geikie Creek	32
R. Picaninny Creek	36
L. Coen River	65
L. Running Creek	20
Watson River	65
R. Lagoon Creek	16
R. Say Creek	18
L. Gumbol Creek	25
L. Kokialah Creek	15
Embley River	28
R. Kurracoo Creek	18
R. Brownstone Creek...	6
R. Spring Creek	7
L. Hey River	12
Mission River	24
R. Myall Creek	30
Pennefather Creek	10
Batavia River	160
R. Sefton Creek	20
L. Clayhole Creek	16
L. Capsize Creek	28
R. Schramm Creek	10
L. Lydia Creek	24
L. Cox Creek	46
R. Nimrod Creek	27
Ducie River	30
R. Palm Creek	24
R North Alice Creek	44
Dulhunty River	52
Skardon River	36
R. McDonnell Creek	6
Jardine River	80
L. McHenry River	26
Cowal Creek	12
Kennedy River	20
Escape River	10
Henderson River	10
Macmillan River	44
Pascoe River	55
Lockhart River	28
L. Greyhound Creek	10
Nesbit Creek	12
R. Leo Creek	9
Chester River	8
Rocky Creek	16
Massy Creek	12
Dinner River	20
L. Breakfast Creek	20
Stewart River	45
L. Station Creek	7
L. Little Stewart Creek	6
Balclutha River	28
Annie River	40
North Kennedy River	76
R Therrimburi Creek	10
L. Station Creek	23
L. Sandy Creek	14
L. Morehead River	65
R. Hann River	52
R. Wangow Creek	20

	MILES
Bizant River	16
Normanby River	162
L. Lakes Creek	16
R. East Normanby River	48
L. Laura River	70
L. Mosman River	30
L. Little Laura River	36
Normanby River (continued)	
L. Kennedy River	70
R. Jack River	16
Marrett River	12
Jeannie River	36
Starcke River	20
McIvor River	32
L. Morgan River	12
Endeavour River...	30
L. North branch	11
L. Right-hand branch	9
Annan River	30
R. Trevethan Creek	10
Esk River	7
Bloomfield River...	30
Daintree River	26
R. Stewart Creek	6
Saltwater Creek	12
Mossman River	12
R. South Mossman River	8
Mowbray River	10
Barron River	70
L. Mazzlin Creek	11
R. Severin Creek	10
L. Rocky Creek	14
R. Tinaroo Creek	13
L. Granite Creek	20
R. Clohesy River	14
L. Flaggy Creek	15
Trinity Inlet	5
Russell River	38
L. Babinda Creek	11
L. Mulgrave River	44
L. Little Mulgrave River... ...	8
R. Tringilburra Creek	16
Johnstone River (North branch) ...	60
Johnstone River (South branch)...	30
Moresby River	10
Liverpool Creek	20
Maria Creek	8
Hull River...	10
Tully River	65
R. Davidson River	8
L. Banyan Creek	8
Murray River	30
Dallachy Creek	9
Wreck Creek	10
Kennedy Creek	14
R. Meunga Creek	6
R. Attie Creek	5
Five Mile Creek	5
Damper Creek	4
Herbert River	150
R. Wild River	30
L. Millstream Creek	28
L. Blunder Creek	42
R. Rudd Creek	18
L. Blencoe Creek	6
R. Garrawalt Creek	16
R. Stone River	28
Palm Swamp	21
Trebonne Creek	26
Saltwater Creek	10
Rollingstone Creek	7
Leichhardt Creek	9
Alice River	20
Black River	17
Bohle River	15
Ross River	30
Alligator Creek	12
Crocodile Creek	7
Houghton River	55
L. Reid River...	20
L. Serpentine Creek	18
Barratta Creek	48
Plantation Creek	19
Burdekin River	440
R. Anthill Creek	24
R. Reedy Creek	10
R. Dry Creek	26
R. Gray Creek	40

Burdekin River (continued)	MILES
R. Clarke River	84
L. Gregory River	20
R. Yates Creek	36
L. Broken River	35
R. Emu Creek	24
R. Maryvale Creek	38
L. Douglas Creek	25
L. Running River	16
L. Star River	18
R. Big Star River	28
L. Little Star River	24
R. Basalt River	80
R. Lolworth Creek	84
L Keelbottom Creek	42
R. Dillon Creek	40
L. Fanning River	35
R. Broughton River	24
L. Pandanus Creek	25
L. Kirk River	20
R. Suttor River	190
R. Rockingham Creek	20
L. Suttor Creek	44
L. Eaglefield Creek	50
R. Verbena Creek	20
L. Logan Creek	45
L. Belyando River	205
L. Native Companion Creek	125
L. Alpha Creek	80
L. Dunda Creek	62
L. Carmichael Creek	48
R. Mistake Creek	122
L. Bully Creek	48
L. Cape River	160
R. Amelia Creek	42
L. Broadley Creek	50
L. Campaspie River	96
R. Blowhard Creek	33
L. Rollston River	38
R. Bowen River	96
R. Broken River	48
R. Bogie River	60
R. Kirknie Creek	10
Wangaratta Creek	13
Rocky Pond Creek	14
Molongle Creek	20
Elliot River	30
Euri Creek	30
Don River	52
Duck Creek	14
Edenlassie Creek	17
Gregory River	16
Proserpine River	30
O'Connell River	28
L. Andromache River	24
Blackrock Creek	17
Murray Creek	28
Victor Creek	7
Seaforth Creek	6
Pioneer River	40
L. Cattle Creek	22
Baker's Creek	13
Sandy Creek	28
Alligator Creek	17
Plane Creek	15
Marion Creek	14
Basin Creek	15
West Hill Creek	15
Carmila Creek	16
Cattle Creek	12
Clairview Creek	17
St. Lawrence Creek	22
Waverley Creek	24
Styx River	40
L. Montrose Creek	14
L. Granite Creek	22
R. Tooloombah Creek	28
R. Stoodleigh Creek	14
Herbert Creek	120
Fitzroy River	174
R. Dawson River	312
R. Hutton Creek	52
R. Eurombah Creek	72
L. Kinnoul Creek	16
R. Juandah Creek	68
L. Palm Tree Creek	50
R. Cockatoo Creek	47
R. Cracow Creek	14
R Castle Creek	40

——Dawson River (continued)	MILES
R. Lonesome Creek	35
R. Granville Creek	32
R. Herbert Creek	24
L. Mackenzie River	170
R. Comet River	80
R. Brown River	50
R. Arcadia Creek	25
R. Clematis Creek	45
L. Christmas Creek	23
L. Consuelo Creek	42
L. Meteor Creek	60
R. Planet Creek	85
R. Humboldt Creek	38
L. Minerva Creek	42
R. Sirius Creek	34
L. Nogoa River	180
L. Claude River	48
R. Buckland Creek	46
L. Balmy Creek	34
R. Vandyke Creek	92
R. Separation Creek	16
L. Anakie Creek	10
R. Stony Creek	20
L. Theresa Creek	130
L. Crinum Creek	16
R. Burngrove Creek	30
R. Blackwater Creek	50
L. Cooroora Creek	34
L. Roper's Creek	56
R. Parker Creek	20
L. Junee Creek	30
L. Isaacs River	152
R. Grosvenor Creek	31
L. North Creek	33
R. Campbell Creek	45
L. Develin Creek	48
R. Rolf Creek	44
L. Connor's River	56
R. Murray Creek	22
L. Collaroy Creek	20
R. Funnel Creek	68
L. Melaleuca Creek	36
R. Gogango Creek	36
R. Emu Creek	12
R. Moah Creek	17
R. Rosewood Creek	15
L. Glenroy Creek	11
L. Marlborough Creek	24
L. Princhester Creek	18
L. Planted Creek	15
L. Canoona Creek	8
L. Alligator Creek	44
L. Moore's Creek	6
R. Gavial Creek	34
L. Nankin Creek	13
Raglan Creek	54
Calliope River	52
L. Alma Creek	12
R. Running Creek	10
L. Harper Creek	12
R. Oaky Creek	18
L. Larcombe Creek	21
R. Double Creek	16
R. Clyde Creek	14
Auckland Inlet	3
South Trees Inlet	12
Boyne River	60
L. Glassford Creek	20
L. Ridler Creek	18
L. Degalgil Creek	26
R. Norton Creek	9
R. Eastern Boyne River	16
L. Futter Creek	24
R. Iveragh Creek	14
Round Hill Creek	6
Baffle Creek	65
R. Three Mile Creek	16
R. Banksia Creek	16
R. Granite Creek	40
R. Murray Creek	15
L. Euleilah Creek	14
R. Bottle Creek	18
Littabella Creek	20
Kolan River	92
R. Gin Gin Creek	52
L. Yandaran Creek	13
Burnett River	250
R. Splinter Creek	50

Burnett River (continued)	MILES
R. Three Moon Creek	78
R. Rawbelle River	65
R. Auburn River	60
R. Boyne River	120
R. Stuart River	68
L. Binjour Creek	14
R. Barambah Creek	130
L. Sunday Creek	34
R. Degilbo Creek	20
L. Perry River	28
L. St. Agnes Creek	18
Elliott River	28
Burrum River	24
L. Cherwell River	16
L. Isis River	20
L. Agnes Vale Creek	16
L. Oaky Creek	15
L. Gregory River	34
R. Sandy Creek	32
Strathdees or Bulbi Creek	7
Mary River	165
L. Little Yabba Creek	17
R. Obi Obi Creek	30
R. Belli Creek	12
L. Yabba Creek	52
R. Skyring Creek	10
L. Kandanga Creek	33
R. Traveston Creek	3
L. Amamoor Creek	28
R. Six Mile Creek	16
R. Deep Creek	10
L. Pie Creek	12
L. Glastonbury Creek	18
L. Widgee Creek	27
R. Curra Creek	15
L. Wide Bay Creek	50
L. Munna Creek	53
L. Ooramera Creek	15
R. Gutchy Creek	20
L. Myrtle Creek	19
L. Graham Creek	10
R. Tinana Creek	68
L. Saltwater Creek	10
L. Susan River	14
Tin Can Inlet	15
Noosa River	30
R. Kin Kin Creek	20
R. Cooloothin Creek	4
R. Ringtail Creek	7
Maroochy River	17
L. North Maroochy River	14
L. Yandina Creek	10
L. Coolum Creek	5
R. Petrie Creek	14
R. Eudlo Creek	9
Mountain Creek	8
Mooloolah River	20
Caboolture River	26
L. Wararba Creek	12
Burpengary Creek	17
North Pine River	30
R. Leacy Creek	9
L. Terrors Creek	7
R. Kobble Creek	10
L. Sideling Creek	8
R. South Pine River	20
R. Samford Creek	6
L. Cedar Creek	10
R. Chinaman Creek	4
Cabbage Tree Creek	10
Nundah Creek	8
Serpentine Creek	7
Brisbane River	200
R. West branch of Brisbane River	18
R. Cooyar Creek	64
L. Yarraman Creek	22
R. Taromeo Creek	15
L. Paradise Creek	6
L. Avoca Creek	20
L. Monsildale Creek	30
L. Kangaroo Creek	12
R. Emu Creek	60
R. Pierce's Creek	10
L. Bum Bum Creek	10
R. Salty Waterholes Creek	12
R. Nukinenda Creek	10
L. Spring Creek	10
L. Neara Creek	10

Brisbane River (continued)	MILES
R. Anduramba or Ivory's Creek	30
R. Cressbrook Creek	36
R. Perseverance Creek	15
L. Crow's Nest Creek	8
L. Stanley River	54
L. Neurum Creek	10
R. Sandy Creek	18
R. Kilcoy Creek	15
R. Sheep Station Creek	16
L. Oaky Creek	9
L. Reedy Creek	14
R. Esk Creek	9
L. Northbrook Creek	12
R. Lockyer Creek	56
R. Murphy's Creek	10
L. Alice Creek	15
R. Flagstone Creek	18
R. Ma Ma Creek	24
R. Tenthill Creek	24
L. Blackfellows Creek	20
R. Laidley Creek	34
L. Buaraba Creek	30
R. Bremer River	50
L. Western Creek	14
R. Franklin Vale Creek	12
R. Warrill Creek	44
R. Reynolds Creek	20
R. Purga Creek	22
R. Deebing Creek	8
R. Bundanba Creek	15
R. Six Mile Creek	6
R. Woogaroo Creek	12
R. Opossum Creek	6
L. Moggill Creek	12
R. Oxley Creek	28
R. Norman Creek	6
L. Breakfast Creek	10
R. Bulimba Creek	16
Tingalpa Creek	12
Hilliard's Creek	8
Eprapah Creek	8
Logan River	96
L. Burnett's Creek	24
R. Palen Creek	12
L. Tamrookum Creek	8
R. Christmas Creek	24
L. Knapps Creek	15
R. Spring Creek	10
L. Allan's Creek	20
L. Teviot Brook	55
R. Scrubby Creek	8
R. Henderson's Creek	8
R. Albert River	54
R. Cainbable Creek	15
R. Coburg River	30
R. Cedar Creek	12
Pimpama River	14
Coomera River	35
Nerang River	34
Mudgeeraba Creek	20
Tallebuggera Creek	15
Currumbin Creek	14
Severn River (to Tenterfield Creek)	48
,, ,, (to Macintyre River)	20
R. Broadwater Creek	15
L. Quartpot Creek	14
L. Bald Rock Creek	15
R. Pike Creek	65
R. Alpin Creek	15
R. Brush Creek	28
R. Macintyre Brook	86
L. Bracker Creek	30
R. Canning Creek	34
L. Catfish Creek	22
Barwon or Macintyre River (along boundary of State)	120
R. Callandoon branch	50
R. Weir River	200
L. Western Creek	50
L. Yarril Creek	50
L. Commoron Creek	76
R. Warril Creek	22
Little Weir River	16
Moonie River	215
L. Toombilla Creek	32
R. Parrie Moolan Creek	25
R. Wongle Wongle Creek	28
R. Farawell Creek	32

	MILES
Moonie River (continued)	
R. Teelba Creek	48
R. Thomby Creek	24
Narran River	32
Bokhara River	32
Balonne Minor River and Murri Murri	32
Balonne River	175
L. Condamine River	320
R. Emu Creek	30
R. Swan Creek	24
L. Rosenthal Creek	28
L. Sandy Creek	25
R. Glengallan Creek	25
R. Dalrymple Creek	35
R. King's Creek	45
L. Thane's Creek	35
L. Canal Creek	35
L. Spiers Creek	15
R. North branch Condamine River	50
R. Oaky Creek	60
R. Myall Creek	50
R. Jimbour Creek	45
L. Wilkie Creek	40
L. Braemar Creek	18
R. Cooranga Creek	40
L. Kogan Creek	28
R. Jingi Jingi Creek	50
R. Charley Creek	46
L. Wambo Creek	45
L. Wieambilla Creek	22
L. Undulla Creek	56
L. Bagot Creek	12
L. Cobblegum Creek	20
L. Murilla Creek	32
R. Dogwood Creek	120
R. Bottle-tree Creek	18
R. Wallan Creek	30
L. Coolumboola Creek	20
R. Drillham Creek	20
R. Dulacca Creek	28
R. Tchanning Creek	68
R. Yuleba Creek	82
R. Wallumbilla Creek	52
L. Griman Creek	20
R. Bungil Creek	92
R. Yalebone Creek	52
L. Weribone Creek	10
R. Cogoon Creek	42
L. Donga Creek	34
R. Tartulla Creek	38
R. Maranoa River	275
R. Western branch	36
R. Billin Creek	30
L. Merrivale River	96
L. Apple-tree Creek	30
R. Mannandilla Creek	40
L. Basalt Creek	18
R. Womalilla Creek	40
L. Amby Creek	36
Ballandool River	40
R. Briarie Creek	24
Culgoa River (Queensland portion)	70
R. Wallam Creek	184
L. Neabul Creek	36
R. Mungallala Creek	245
R. Nebine Creek	176
L. Patterson Creek	80
R. Widgeegoara Creek	120
Noorama Creek	115
Thurrulgoonia Creek	50
Blackfellow Creek	32
Tuen Creek	32
Owangowan Creek	14
Warrego River (Queensland portion)	365
R. Nive River	112
R. Ward River	115
R. Langlo River	112
L. Angellala River	136
R. Nemunmulla Creek	60
Cuttaburra Creek	64
Paroo River	228
L. Quilberry Creek	36
R. Beechal Creek	70
L. Mirraparoo Creek	36
R. Yowah Creek	60
Mirintu Creek	48
Titheroo Creek	24
Booka Booka Creek	32
Bulloo River	370

	MILES
ulloo River (continued)	
L. Blackwater Creek	42
R. Durella Creek	32
R. Nickavilla Creek	36
L. Winbin Creek	58
R. Coorni Paroo Creek	52
L. Goora Goora Creek	28
R. Moble Creek	60
R. Moolianna Creek	44
R. Gumbo Creek	52
L. Macintyre Creek	30
R. Neerebah Creek	10
R. Pitteroo Creek	36
Warry Warry Creek	50
Cooper's Creek	270
R. Thomson River	240
L. Cornish Creek	44
R. Tower Hill Creek	98
R. Landsborough Creek	116
R. Bangall Creek	64
R. Bradley Creek	46
L. Aramac Creek	82
L. Black Gin Creek	48
L. Wellshot Creek	24
L. Ernestina Creek	32
R. Darr River	100
R. Maneroo Creek	64
R. Catherine Creek	64
L. Tocal Creek	36
R. Acheron Creek	38
R. Vergemont Creek	116
R. Warbreccan Creek	36
R. Carella Creek	36
L. Bostock Creek	40
R. Wuringle Creek	48
L. Barcoo River	310
R. Birkhead Creek	40
L. Macfarlane Creek	36
L. Boree Creek	44
L. Ravensbourne Creek	72
R. Douglas Ponds Creek	56
R. Alice River	144
L. Jordan Creek	64
R Lagoon Creek	28
L. Patrick Creek	40
L. Thornleigh Creek	68
R. Wild Horse Creek	52
L. Fallundilly Creek	48
L Pemberley Creek	30
L. Minster Creek	20
L. Powell Creek	90
L. Wombunderry Channel (or Eastern branch)	116
L. Tooratchie Creek	24
L. Wilson River	190
Brown's Creek	36
Diamantina River	468
L. Western River	84
R. Oondooroo Creek	28
R. Mills Creek	72
L. Mistake Creek	36
L. Lydia Creek	20
R. Wokingham Creek	90
L. Cameron Creek	24
R. Cadell Creek	72
L. Kell Creek	36
L. McBride Creek	40
R. Mackunda Creek	68
L. Mayne River	100
L. Binburi Creek	32
R. North Creek	44
L. Eden Creek	32
L. Edkins Creek	48
L. Farrar's Creek	200
Eyre Creek	260
R. Georgina River (including the part in South Australia)	368
L. Buckley River	88
L. Templeton River	100
L. Yaringa Creek	72
L. Moonah Creek	88
L. St. Ronans Creek	50
R. Pituri Creek	80
L. Burke River	160
L. Mort River	52
R. Wills Creek	92
L. Hamilton River	160
R. Mulligan River	192

5D. **South Australia.**—Starting at the south-eastern extremity and going westerly and northerly.

	MILES.		MILES.
Murray River (South Australian portion)	400	Hindmarsh River	15
Onkaparinga River	60	Inman River	17
Stuart River	17	Cygnet River	38
Torrens River	50	Willochra River	110
Little Para Creek	20	Pasmore River	100
Gawler River	80	Frome River	150
Light River...	100	Clayton River	55
Wakefield River	65	Cooper or Barcoo River (S.A. portion) ...	300
Broughton River	90	Warburton River (S.A. portion)	275
Tod River	26	Treuer or Macumba River	145
Bremer River	40	Neale's River	200
Angas River	26	Officer River	100
Finniss River	30		

5E. **Northern Territory.**—Starting at the north-eastern extremity and going westerly and southerly.

McArthur River	125	South Alligator River	100
Limmen Bight River	140	Mary River...	100
Roper River	260	Adelaide River	110
R. Strangway's River	85	Daly River	225
L. Chambers Creek	85	Fitzmaurice River	100
R. The Birdum Creek	120	Victoria River	350
Goyder River	90	L. Wickham River	75
Liverpool River	80	L. Gordon River	65

5F. **Western Australia.**—Starting at north-eastern extremity and going westerly, southerly, and easterly.

Ord River...	300	Ashburton River (continued)	
L. Bow River...	80	R. Duck River	75
Pentecost River	50	R. Hardey River	135
L. Chamberlain River	125	Lyndon River	140
Durack River	160	Gascoyne River	475
Drysdale River	275	R. Lyons River	225
King Edward River	150	Wooramel River	150
R. Carson River	85	Murchison River	440
Moran River	50	L. Sanford River...	110
Isdell River	115	L. Roderick River	80
Lennard River	165	Greenough River	170
Fitzroy River	325	Moore River	100
L. Jurgurra River	90	Swan River (upper portion called Avon Riv.)	240
L. Christmas River	165	L. Helena River	40
L. Margaret River	430	Murray River	70
R. Adcock River	75	Collie River	60
R. Hann River	130	Preston River	40
De Grey River	190	Blackwood River	190
L. Shaw River	135	Warren River	55
L. Coorgan River	110	Frankland River	80
R. Oakover River	180	Kalgan River	65
Turner River	75	Pallinup River	75
Yule River	140	Cairdner River	70
Fortescue River	340	Fitzgerald River	40
Robe River	75	Phillips River	45
Cane River	65	Oldfield River	50
Ashburton River	220	Young River	40
L. Henry River	75	Lort River	50

5G. **Tasmania.**—Starting at the north-eastern extremity and going westerly, southerly, easterly, and northerly.

Ringarooma River	62	Franklin River	16
Boobyalla River	26	Rubicon River	22
Tomahawk River...	16	Mersey River	60
Great Forester River	38	L. Dasher River	17
Brid River	26	Don River	20
Little Forester River	27	Forth River	52
Piper's River	30	L. Dove River	14
Tamar River (formed by junction of North and South Esks)	40	Gawler River	15
		Leven River	50
North Esk River	45	Blythe River	30
R. St. Patrick's River...	30	Emu River	24
South Esk River	120	Cam River	25
L. Lake River	45	Inglis River	25
L. Macquarie River	73	Detention River	15
R. Elizabeth River	35	Black River	16
R. Nile River...	25	Duck River	17
R. Ben Lomond River	18	Montague River	23
L. St. Paul River	28	Welcome River	14

	MILES		MILES
Arthur River	63	Old River	16
L. Frankland River	27	Lune River	16
L. Helder River	24	Esperance River	14
L. Hellyer River	23	Huon River	105
Pieman River (formed by junction of the Murchison and Mackintosh Rivers)	40	R. Picton River	30
Mackintosh River	22	Derwent River	107
Murchison River	23	L. Jordan River	58
Little Henty River	14	R. Styx River	22
Henty River	25	R. Russell's Falls River	24
King River	31	L. Clyde River	45
Gordon River	90	L. Ouse River	62
R. Franklin River	61	L. Dee River	20
L. Sprent River	23	L. Nive River	40
R. Denison River	31	Coal River	40
L. Wedge River	16	Carlton River	16
Spero River	22	Prosser River	25
Wanderer River	16	Little Swanport River	33
Mainwaring River	18	Lisdillon River	12
Rocky River	18	Meredith River	13
Giblin River	14	Swan River	22
Davey River	23	Apsley River	16
R. Hardwood River	22	Scamander River	16
Spring River	18	George River	29
North River	14	Anson River	22
		Great Mussel Roe River	31

(ii.) *Lakes.* The "lakes" of Australia may be divided into three classes, viz., (*a*) true permanent lakes; (*b*) lakes which being very shallow, become mere morasses in dry seasons, or even dry up and finally present a cracked surface of salt and dry mud, and (*c*) lakes which are really inlets of the ocean, opening out into a lake-like expanse.

The second class (*b*) is the only one which seems to demand special mention. These are a characteristic of the great central plain of Australia. Some of them (*e.g.*, Lake Torrens, Gairdner, Eyre, Frome) are of considerable extent.

(iii.) *Artesian Areas.* A considerable tract of the plain country of New South Wales and of Queensland carries a water-bearing stratum, usually at a great depth. A large number of artesian bores have been put down, from which there is now a considerable efflux. These are of great value, and render large areas available which otherwise would be difficult to occupy even for pastoral purposes. Western Australia has also an artesian area of considerable magnitude.

The distribution of the rivers and lakes, and the approximate boundaries of the artesian basin, are shewn on the accompanying map.

The statistics relating to artesian bores will be given *in extenso* hereinafter, viz., in the section dealing with Water Conservation.

6. **Orography.**—Owing to the absence of any very high mountain chains, and to the great depression in the centre of Australia, the average elevation of the Australian continent over the level of the surrounding oceans is less than that of any of the other continents. This average, however, has not yet been estimated with any degree of precision.

(i.) *General Description of the Surface.* A section through the continent from east to west, at the point of its greatest breadth, shews first a narrow belt of coastal plain. This plain, extending north and south along the whole eastern coast, is well watered by rivers. Of variable width, seldom more than sixty or seventy miles, and occasionally only a few miles or disappearing altogether, its average may, nevertheless, be taken as about forty to fifty. From this the Great Dividing Range, or Australian Highlands, extending from the north of Queensland to the south of New South Wales, and thence sweeping westward through Victoria, rises often sharply, and frequently presents bold escarpments on its eastern face. The descent on its western slopes is gradual, until in the country to the north of Spencer's Gulf the plain is not above the sea-level, and occasionally is even below it. Then there is another almost imperceptible rise until the mountain ranges of Western Australia are reached, and beyond these another strip of coastal plain.

The great central plain is the most distinctive feature of the Australian continent, and its climatic peculiarities are doubtless to be largely ascribed thereto.

(ii.) *Mountain Systems.* The main mountain feature of Australia is the Great Dividing Range, which runs along the whole eastern coast of the continent, and can be traced over the islands of Torres Straits to New Guinea, while in the South one branch sweeps westwards towards the boundary of Victoria and South Australia, and the other—the main branch—finds its termination in Tasmania.

This main mountain system is, at no place, more than 250 miles from the eastern coast-line, and it approaches to within 27 miles. On the whole it is much closer to the coast in both New South Wales and Victoria than it is in Queensland, the corresponding average distances being about 70, 65, and 130 miles respectively.

The mountains of Australia are of relatively small altitude. Thus in Queensland the Great Dividing Range reaches a height above sea-level of only 5440 feet (Mount Bartle Frere). In New South Wales Mount Kosciusko is only about 7300 feet, and Mount Bogong in Victoria only about 6510 feet high. The fact that there are no high mountains in Australia is also an important element in considering its climate.

There is no connection between the mountains of the eastern and other States of Australia. In South Australia there are two peaks rising to about 3005 feet (Mount Remarkable and Mount Brown); and in Western Australia the height of 3800 feet (Mount Bruce) is attained. In Tasmania the greatest height is only 5070 feet (Cradle Mountain).

It may be of interest to observe that at one time Tasmania was doubtless connected with the mainland. As the Great Dividing Range can in the north be traced from Cape York across Torres Straits to New Guinea, so can its main axis be similarly followed across the shallow waters of Bass Straits and its islands from Wilson's Promontory to Tasmania, which may be said to be completely occupied by ramifications of the chain. The central part of the island is occupied by an elevated plateau, somewhat triangular in shape, and presenting bold fronts to the east, west, and north. This does not extend in any direction more than about sixty miles. The plateau rests upon a more extensive tableland, the contour of which closely follows the coast-line, and occasionally broadens out into low-lying tracts not much above sea-level. The extreme south of the island is rugged in character.

The positions of the mountain ranges are shewn on the map, specially illustrating Australian orography.

§ 2. The Geology of Australia.

1. **General.**—The geology of different parts of Australia has, naturally, been studied with varying degrees of thoroughness. The great area to be covered, the difficulties to be encountered, and the limited time so far available, are obvious. Instead of attempting, therefore, to present in bold outline a general picture of Australian Geology, it is proposed to give authoritative, independent sketches of the geology of each State, notwithstanding that this will necessarily involve some degree of repetition.

A knowledge of the main features of Australian physical geography will be assumed, and references thereto consequently reduced to a minimum.

2. **Geology of New South Wales.**[1]—In physical configuration New South Wales may be divided into three regions, viz.:—(1) The narrow coastal plain on the east; (2) the Great Dividing Range and its associated table-lands; and (3) the western plains. These will first be individually referred to.

(i.) *The Main Dividing Range.* The main dividing range or table-land of New South Wales is composed for the main part of Palæozoic sediments, together with granitic and other igneous rocks; that portion of it, however, which is situated to the westward of Maitland, Sydney, and Wollongong, is capped with Mesozoic strata, viz., the Hawkesbury series, forming the covering of the principal coal basin.

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(ii.) *The Coastal Plains.* The coastal plains, which extend from the eastern foothills of the Dividing Range to the ocean, and which vary in width from a mile or two up to 150 miles, contain two coal-bearing basins, the chief of which extends from the neighbourhood of Maitland on the north to the Shoalhaven River on the south. This coal basin consists of the Permo-Carboniferous coal measures overlaid by the Hawkesbury (Triassic) series. The second coal-field referred to is that known as the Clarence and Richmond field. It is composed of Triassic or Trias-Jura rocks, and so far as at present known it contains no coal seams of commercial value. It may, however, be underlain by the productive Permo-Carboniferous measures.

The coastal plains are also largely composed of Post-Tertiary fluviatile deposits, which form exceedingly rich agricultural areas. A considerable area between the Richmond and the Tweed Rivers is occupied by basalt, the decomposition of which has produced a rich soil eminently suitable for agriculture and dairy farming.

(iii.) *The Great Western Plains.* The great western plains, which extend from the western foothills of the great tableland, are underlain by granitic rocks and sediments of Palæozoic, Mesozoic, and early Tertiary age. The most northerly portion is Mesozoic (Triassic), and forms the artesian water-basin. South of this is a Palæozoic belt stretching westerly from the great tableland to the South Australian border. During the Mesozoic era this belt formed a mountain range, whose direction was at right angles to the main divide; but this range was subsequently planed down by denudation, and its surface is now level with the surrounding country. To the south of this, along the Lower Darling and the Murray, is a large area of early Tertiary marine beds (Eocene), while the remainder of the Riverina district (up the Murray, Murrumbidgee, and Lachlan Rivers) is underlain for the most part by granitic, Silurian, and Devonian rocks.

The surface of the western plains is covered by Post-Tertiary deposits, flood loams, etc., except in isolated places where the remains of the older formations still rise above their surface.

(iv.) *Classification of the Sedimentary Rocks of New South Wales.* In the following classification some indication of the economic significance of the different members of each series is given :—

CAINOZOIC.	Post-Tertiary.	Recent; auriferous and stanniferous soils and alluvial deposits in the beds of existing rivers.	
		Pleistocene; alluvial leads containing gold, tin and gem-stones.	
	Tertiary.	Pliocene; alluvial leads, frequently covered by basalt, and containing gold, tin and gem-stones.	
		Miocene; quartzites with plant remains at Dalton, near Gunning.	
		Eocene; marine limestones and calcareous sandstones of the Lower Darling; plant beds of the New England district.	
MESOZOIC.	Cretaceous.	Upper Cretaceous (desert sandstone); contains deposits of precious opal.	
		Middle Cretaceous; auriferous alluvial leads at Mount Brown.	
		Lower Cretaceous (Rolling Downs formation of Queensland).	
	Jurassic.	Talbragar fish-bearing shales.	
	Triassic.	The Ipswich coal measures and the Clarence coal measures.	Form the base of the artesian water-bearing basin. These measures contain thin coal seams, not at present worked in New South Wales.
		Hawkesbury series.	Wiannamatta shales (contain fire-clays).
			Hawkesbury sandstones (building stone).
			Narrabeen shales.

PALÆOZOIC.	Permo-Carboniferous.	1. Upper or Newcastle coal measures. 2. Dempsey series. 3. Middle or Tomago coal measures. 4. Upper marine series. 5. Greta coal measures. 6. Lower marine series.	The productive coal seams of New South Wales occur in these measures.
	Carboniferous.	Rhacopteris beds and associated marine beds. Gympie claystones (of Queensland).	All the metalliferous lodes and reefs occur in these formations, or in such igneous rocks as granites, quartz - porphyries, felsites, diorites, etc.
	Devonian.	Upper Devonian. Lower Devonian.	
	Silurian.	Limestones and slates at Yass, Molong, Wellington, Quidong, etc.	
	Ordovician.	Slates and tuffs at Mandurama, Cadia, Tomingley, Berridale, and in the counties of Auckland and Wellesley, on the Victorian border.	
	Cambrian.	Limestones, schists and glacial beds of Terrawingee.	

(v.) *Cambrian System.* The oldest sedimentary rocks of New South Wales are probably those forming the Barrier Ranges in the far west. No organic remains have yet been found in them, and their geological age has been a matter of speculation for many years. Quite recently Mr. Mawson, of Adelaide, has stated that he has traced the Lower Cambrian beds of South Australia to Terrawingee, north of Broken Hill, and he also considers that the metamorphic rocks of Broken Hill may be of pre-Cambrian age. These statements have not yet been confirmed by the New South Wales Geological Survey, though it is quite possible they are correct.

The rocks at Broken Hill consist of a laminated series of crystalline gneisses, quartzites, micaceous and hornblendic schists, and garnet sandstones. Broken Hill itself is a low range in which these rocks have been folded into an anticline. The great Broken Hill lode occupies the saddle-shaped cavity caused by the folding of the strata as stated, but the saddle lode is now of larger dimensions than the original cavity, owing to the gradual replacement (metasomatism) of the country rock forming the walls by ores of lead, silver, and zinc.

To the north of Broken Hill the metamorphic rocks just described give place—in an unbroken series—to less altered slates and schists, traversed by tin-bearing dykes of coarse pegmatite, as at Euriowie, while at Terrawingee there are massive beds of blue limestone (and, according to Mr. Mawson, glacial till), which apparently belong to the same series.

(vi.) *Ordovician System.* At the Lyndhurst goldfields, near Mandurama, occurs a series of banded sedimentary rocks, consisting of indurated bluish grey claystones alternating with highly altered volcanic tuffs. The claystones contain Trilobites (agnostidæ), Brachiopods (obolella), Pteropods (hyolithes), Graptolites (diplograptus, dicellograptus, climacograptus, etc.), and remains of Radiolaria. The tuff beds, which vary from the thickness of paper up to 20 feet, contain bunches and impregnations of auriferous sulphides, and are worked for gold.

The series of banded rocks has been intruded by sills and dykes of hornblende, andesite, etc., which are apparently offshoots from a large body of hornblendic granite. The intrusions appear to have occurred while the sediments were still in a plastic condition, for the tuffs have been so forced into the claystones as to give the former the appearance of being intrusive.

Dark blue claystones and slates containing similar Graptolites also occur at Tomingley, Cadia, Berridale, and on the Victorian border—counties of Auckland and Wellesley. At Tomingley the slates are intersected by auriferous quartz reefs.

(vii.) *Silurian System.* Silurian rocks cover a large area of New South Wales, but the locality where they can be most satisfactorily studied is between Yass and the

Murrumbidgee River. There they consist of a considerable thickness of slates, sandstones, and limestones, with numerous characteristic fossils, such as Trilobites, Corals, Echinoderms, Brachiopoda, and Mollusca.

The celebrated auriferous reefs at Hill End, Tambaroora, and Hargraves occur in Silurian rocks, consisting of slates with interbedded volcanic tuffs, the latter being fossiliferous at Hill End. The Silurian rocks have been intruded, altered, and disturbed by granites, felspar porphyries, etc.

(viii.) *The Devonian System.* The Silurian slates and limestones to the south of Yass are succeeded by a belt of lavas (rhyolites, etc.) and tuffs, which separate them from a newer series of blue limestones, quartzites, and slates containing fossils of Lower Devonian affinities. At Wellington also the junction can be seen between Silurian and Lower Devonian rocks. At Tamworth, rocks of the same age as the Carboniferous of Europe are underlain by a series of banded claystone and volcanic tuffs, with occasional beds of limestone and intrusive sills of granite. The claystones contain numerous Radiolarian remains, while in the tuffs is found the plant *Lepidodendron australe*, and the limestones contain an abundant fossil fauna, including corals, which enable these beds to be correlated with the Upper Devonian of Queensland. A good section of Upper Devonian quartzites and shales containing *Lepidodendron australe* and numerous marine fossils can also be seen at Mount Lambie, near Rydal.

The Devonian system is characterised by the prevalence of grey and red quartzites and grits, and vary large areas of the southern half of the State are covered by these rocks.

(ix.) *The Carboniferous System.* A considerable area of the coastal plain and tableland north of Newcastle is occupied by bluish claystones and tuffs, with occasional belts of limestones, corresponding in age with the Lower Carboniferous rocks of Europe. Near Port Stephens they contain interbedded deposits of Magnetite, which, however, contains a considerable percentage of Titanium, whereby its value as an iron ore is reduced. At Copeland and several other goldfields the claystones are intersected by gold-bearing reefs. The plant *Lepidodendron australe* is fairly common in Lower Carboniferous rocks as well as in the Upper Devonian.

In the neighbourhood of Stroud is an area of shales, sandstones, and cherts containing abundant impressions of *Rhacopteris*, and these beds have been classified as Upper Carboniferous. No workable seams of coal have been found in the Carboniferous system, though in the *Rhacopteris* series near Stroud several very inferior seams with numerous bands are known.

(x.) *The Permo-Carboniferous System.* The productive coal measures of New South Wales contain fossil remains, shewing affinities to both the Permian and Carboniferous systems of Europe, hence the composite name which has been given to them.[c] The measures are about 15,000 feet in thickness and have been classified as follows:—

(*a*) *Upper or Newcastle Coal Measures*, containing an aggregate of about 100 feet of coal.

(*b*) *Dempsey Series:* freshwater beds containing no productive coal. This series thins out completely in certain directions.

(*c*) *Middle, or Tomago, or East Maitland Coal Measures*, containing an aggregate of about 40 feet of coal.

(*d*) *Upper Marine Series:* sandstones and shales specially characterised by the predominance of the brachiopod *Productus brachythœtus.* At Branxton traces of glacial action have been seen in these beds.

(*e*) *Lower or Greta Coal Measures*, containing from 20 to 40 feet of coal.

(*f*) *Lower Marine Series:* sandstones and shales: specially characterised by the mollusc *Eurydesma cordata.* Glaciated boulders and erratics have been found in these beds at Lochinvar.

The three coal-bearing series contain numerous plant remains, including *Glossopteris*, *Gangamopteris*, *Phyllotheca*, *Nœggerathiopsis*, etc., while the Lower and Upper Marine series are characterised by an abundant fauna. The Permo-Carboniferous coal basin occupies an area of about 25,000 square miles extending to the north, west, and south of Sydney, and is the storehouse of one of the State's most valuable assets. In several collieries near West Maitland very fine seams of coal of 20 feet and upwards are being worked. A narrow isolated deposit of the Permo-Carboniferous system extends from near Inverell to the Queensland border. It contains a fine seam of coal (27 feet thick in places), which probably belongs to the Greta series. These measures lie unconformably upon altered claystones of Lower Carboniferous age, and have been intruded by granite which has tilted the coal seam to an angle of about 40 degrees.

(xi.) *The Triassic System*. The Permo-Carboniferous coal basin is overlain in most places by a thickness of over 1000 feet of shales and thick-bedded sandstones. There is no apparent stratigraphical unconformity between these beds and the underlying coal measures, nevertheless there is a very decided break in the fossil life, and the fauna and flora of the newer beds have been correlated with the Triassic system of Europe. These shales and sandstones have been named the Hawkesbury series, and have been subdivided as follows in descending order:—

(*a*) *Wiannamatta Shales*. Blue, red, and grey shales, with occasional beds of sandstone. These shales are used for the manufacture of bricks and tiles, and some have the qualities of fireclay.

(*b*) *Hawkesbury Sandstones*. Thick-bedded greyish-white freestones, used commonly about Sydney for building purposes.

(*c*) *Narrabeen Shales*. Beds of chocolate-coloured shales and greenish tuffs varying from a foot or so to about 1800 feet in thickness. These shales form a very definite and persistent horizon.

The Clarence River coal basin is composed of rocks closely resembling the Hawkesbury series, and they are regarded as contemporaneous, thus the—

(*d*) Upper Clarence shales may be the equivalents of the Wiannamatta shales.
(*e*) Clarence sandstones ,, ,, Hawkesbury sandstones.
(*f*) Lower Clarence shales ,, ,, Narrabeen shales.

It should be noted, however, that while the Clarence River series contains the fossil plants *Tæniopteris daintreei* and *Thinnfeldia odontopteroides*, the first-named has never been found in the Hawkesbury series, though *Thinnfeldia* is common in these rocks. It is possible, therefore, that the Clarence series may be newer than the Hawkesbury.

There are numerous seams of coal in the Clarence Measures, but they are too thin and their quality too inferior to be of commercial value. It is very probable, however, that these Triassic rocks may be underlain by the Permo-Carboniferous Coal Measures, which may mean a considerable addition to the coal resources of the State. The Clarence Coal Measures extend through Southern Queensland to the western flanks of the tableland of New South Wales, and dip thence under the north-western plains, forming the great artesian basin.

(xii.) *Jurassic System*. About 20 miles north-east of Gulgong is a small lacustrine deposit of thin-bedded yellow shales containing plants and fish remains which are considered to be Jurassic. The deposit referred to lies unconformably upon massive beds of Hawkesbury sandstone; it is of small extent and is the only known representative of the Jurassic in the State. Amongst the fossil plants are *Tæniopteris daintreei*, *Podozamites lanceolatus*, *Alethopteris australis*, *Thinnfeldia falcata*, and *Baiera bidens*: the fish include *Leptolepis gregarius*, *Archæomene robustus*, *Coccolepis*, etc.

(xiii.) *Cretaceous System* The Rolling Downs formation of Queensland, which has been classified as Lower Cretaceous, and which consists of a series of shales, limestones and sandstones, is not known to outcrop at the surface anywhere in New South Wales, but its characteristic fossils have been met with in wells at Yandama, in the Milparinka district, and a solid core from the Wallon bore, in the Moree district, shows that the drill penetrated about 1500 feet of Lower Cretaceous sediments there. It is possible, therefore, that these rocks underlie some considerable portion of the north-western plains.

The desert sandstones formation, which is believed to belong to the Upper Cretaceous epoch, is of very widespread occurrence over the north-western plains. There is a very marked stratigraphical unconformity between it and the Lower Cretaceous series, though there seems to be no practical distinction in regard to fossil life in the two formations. The most important fossils include—*Isocrinus*, *Maccoyella*. *Pseudavicula*, *Belemnites*, *Ancycloceras*, *Crioceras*, and *Cimoliosaurus*. The desert sandstone is generally horizontally bedded, and occurs as isolated hills and low ranges. Two varieties of rock are particularly noticeable, one being a greyish-white freestone, while the other is a vitreous rock of the character of porcellanite. Occasional beds of conglomerate occur, containing pebbles of quartz, agate, and chalcedony, and there is also a soft, fine-grained, siliceous rock having somewhat the appearance of kaolin. At White Cliffs, in the Wilcannia district, and at Lightning Ridge, north of Walgett, precious opal occurs in this rock. and extensive mining operations are carried on there.

(xiv.) *Tertiary System.* (*a*) *Eocene.* In the south-western portion of the State, along the course of the Lower Darling and Murray Rivers, there is a large area of marine calcareous sandstones, which have been classified as Eocene. In the Arumpo bore these beds have been proved to be at least 900 feet thick, the fossil *Trigonia semiundulata* being found at that depth.

At Tooraweenah, Warrumbungle Mountains, a lacustrine deposit, consisting of two series of shales and sandstones, occurs, containing Eocene plant remains. The two series of beds are separated by a flow of trachytic lava, and a similar lava covers the upper beds.

In New England (at Elsmore, Emmaville, etc.) Eocene leaves are found in fluviatile deposits (tin-bearing gravels) covered by basalt.

(*b*) *Miocene.* At Dalton, near Gunning, there is a lacustrine deposit of quartzite which has been classified as Miocene, on account of the plant remains found therein.

(*c*) *Pliocene.* Deep auriferous leads at Gulgong and Forest Reefs have been found to contain Pliocene plant remains—seeds, etc. These deposits are mostly covered by basalt. Most of the Tertiary deposits are of lacustrine or fluviatile origin, and they are important chiefly on account of the alluvial gold and tin ore, as well as diamonds, contained in them.

(xv.) *Post-Tertiary.* Much of the alluvial gold, tin ore, and gems has been found in Post-Tertiary soils and gravels. These are for the most part shallow, and their contents have been easily recovered by the miners.

Pleistocene surface deposits cover great areas of the western plains, and are the means of obscuring the underlying geological formations and rendering prospecting operations difficult. At Mount Kosciusko there are evidences of much glaciation during Post-Tertiary times—striated boulders are very numerous, and glaciated pavements, *roches moutonnées*, and terminal and lateral moraines occur in a good state of preservation.

3. **Geology of Victoria.**[1]—The State of Victoria is of irregular shape, with the narrowest part to the east. Near the eastern end the Great Dividing Range enters, running south-westerly and westerly, being on the whole most rugged and of greatest altitude as it enters Victoria, *i.e.*, the general height falls as it runs westerly. On the whole also its southern faces are more steep than its northern, and as the Murray River is approached the character of the country is identical with that of the western plains of New South Wales.

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1. This article was contributed by E. J. Dunn, Esquire, F.G.S., Director of the Geological Survey of Victoria.

(i.) *Geological Formations found in Victoria.* The following are the geological formations appearing in Victoria :—

SEDIMENTARY.

CAINOZOIC ...	Recent; Post-Pliocene; Pliocene—newer and older; Miocene; Eocene.
MESOZOIC ...	Jurassic.
PALÆOZOIC ...	Permo-Carboniferous; Carboniferous; Devonian; Silurian—Yeringian and Melbournian; Ordovician—Upper and Lower Darriwill, Castlemaine, Bendigo, Lancefield zones; Cambrian—Heathcotian.

METAMORPHIC.

PALÆOZOIC ...	Schists.
ARCHÆAN ...	Schists and gneiss.

IGNEOUS.

VOLCANIC ...	Basic—Older and Newer Basalt; Acidic—Dacite, etc.
PLUTONIC ...	Basic—Gabbro, etc.; Acidic—Granite, Syenite, Grano-diorite, etc.
DYKES ...	Basic; Acid.

The metamorphic and sedimentary series will be referred to in detail in the inverse order of the tabular statement.

(ii.) *Archæan System.* The Archæan system includes gneiss, schists, etc.

(*a*) *Gneiss.* In the vicinity of Barnawatha, Omeo, Bethanga, and Yackandandah there is an ancient system of rocks that are partly gneissic. White mica and garnets occur abundantly in them, and they are pierced by pegmatite, euritic, and other dykes. These rocks appear to be the most altered of the metamorphic series, and are more granitic in character than the schists of Yackandandah. At Cookimburra, Granya, and Bethanga, sulphides of lead, copper, iron, zinc, etc., together with gold and silver, have been found associated with the gneissic rocks, in lodes and disseminated. The soil is of poor quality in places, but of rich character about Bethanga.

(*b*) *Schists.* In many parts of Victoria schists have resulted from the alteration of the Silurian and Ordovician rocks caused by granite intrusions. Such schists may be seen at Maldon, south of Bendigo, Buxton, Beechworth, Omeo, Cassilis, etc. To the north of Yackandandah, however, there is a large area of schist which appears to be pre-Ordovician. The schist is much contorted and crumpled, and is characterised by a black mica. It differs widely from the adjacent Ordovician rocks exposed at Hillsborough, etc.

Schists occur over a great portion of the east of the State, and also are found in the south-west, but, so far, the Archæan schists have not been separated from the less ancient series by mapping, although very distinct on the ground.

Economically the schists are important on account of the mineral lodes associated with them. Gold, silver, copper, zinc, lead, arsenic, etc., are found at Cassilis, for instance. The Yackandandah schists have not hitherto proved rich in valuable minerals, but the contact schists often carry auriferous lodes, as at Maldon, Stawell, etc. Limestones have not been observed in this series.

(iii.) *Palæozoic.* The Palæozoic rocks include the following, viz. :—Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permo-Carboniferous.

(*a*) *Heathcotian. Cambrian (?)* The Heathcotian rocks were first observed and separated from the Ordovician and Silurian beds in the neighbourhood of Heathcote, hence the name applied to them by Professor Gregory. They consist of much altered and contorted cherty beds, full of thin, ramifying quartz veins, and of jaspers coloured red, green, yellow, etc., associated with interbedded and intrusive diabases, serpentines, porphyrites, agglomerates and tuffs. Similar rocks occur in the Mount Camel Range, past Toolleen, as far as Lake Cooper; in Gippsland, at Mount Tara, Accommodation Creek, near Mount Deddick, Limestone Creek, Nowa Nowa; at Green Hill and the Dog Rocks, near Geelong; and possibly at Waratah Bay, Mount Wellington, and near Wood's Point. They are separated from the Ordovician rocks by a distinct unconformity.

Gold, silver, copper, lead, zinc, and iron ores have been found associated with this series. Iron ores may be mentioned at the Iron Mask mine, near Mount Tara, Nowa Nowa, and Dookie.

Distinct from the typical Heathcotian series, but probably Cambrian, are the phosphatic rocks of Mansfield. The phosphate is wavellite (phosphate of alumina). Barytes in veins and lodes is of common occurrence in the Heathcotian.

(b) *Ordovician*. Beds of this age outcrop at the surface over two considerable areas, one in the eastern part of the State and the other west of the meridian passing through Melbourne. They are composed of fine to coarse-grained sandstones, grits, slates, and shales, with rare thin beds of limestone and occasionally conglomerate, and are bent into a series of synclinal and anticlinal folds, and much faulted. The two Ordovician areas together cover about one-fifth of the State. They are of vast thickness, but there is no reliable data on which to base an estimate.

The Ordovician is the gold-bearing formation of Victoria. Most of the gold, since its discovery 56 years ago, has been won from Quartz reefs in these rocks, or from alluvial deposits formed from their disintegration. The western area is the richer of the two, and includes such famous goldfields as Ballarat, Bendigo, Dunolly, Castlemaine, Maryborough, etc. The usual matrix of the gold is quartz.

Bendigo is famous for its saddle reefs—quartz reefs that conform to the bedding in the arches of the anticlinal folds and less frequently in the synclinal folds. These occur one beneath the other, and have been worked from the surface down to a depth of 4250 feet. Along the anticlinals they have been traced for about 20 miles. A feature of this goldfield is the occurrence of basic dykes (limburgite) along the axis of the anticlines. The Berringa goldfield is marked by similar features.

Ballarat is remarkable for the vast quantity of gold which has been yielded from its deep and shallow alluvial deposits from the date of its discovery to the present time. Some of the nuggets were of great size.

A feature of the reef gold in Ballarat is that it occurs in connection with "indicators." These indicators are certain "beds," interlaminated with the usual slates, mudstones, sandstones, etc. When a quartz vein cuts across an indicator it is usually found to be enriched at the point of intersection. The other portions of the vein may be barren or very poor. The Tarnagulla district has long been famous for large gold nuggets, and has lately had public attention redirected to it by the Nick o' Time and Poseidon rushes. Probably these masses of gold come from indicator lines, but so far they have only been found in alluvial deposits. It is reasonable to expect that similar masses of gold remain in their original matrix. Other localities for large nuggets are Moliagul, where the "Welcome Stranger" nugget (2315 ozs.) was found and sold at the local bank for £9436 16s. 8d.; Rheola, or Berlin rush, also is famous for its great nuggets.

Intrusions of granitic rocks are frequent in the Ordovician series, and they are also cut through by numerous acid and basic dykes.

(c) *Ordovician Fossils.* The following are amongst the typical fossils:—Upper Ordovician: *Stephanograptus gracilis, Dicellograptus elegans, Climacograptus bicornis, Glossograptus hermani.* Lower Ordovician: *Dictyonema pulchellum, Didymograptus caduceus, Tetragraptus serra, T. quadribrachiatus, Goniograptus macer, Clonograptus rigidus, Trigonograptus wilkinsoni, Phyllograptus typus, Siphonotreta maccoyi, Saccocaris tetragona, Rhinopterocaris maccoyi, Dinesus ida.*

(d) *Silurian.* The Silurian rocks occur between the two great Ordovician outcrops, and occupy about half the area of the latter. They are divided into the upper, or Yeringian, and the lower, or Melbournian, series. Members of the upper division occur in the extreme east of the State at Limestone Creek, and at Wombat Creek, Mitta Mitta River, and Walhalla.

The beds consist of varieties of sandstone, slate, mudstone, etc. Some of the sandstones are reddish or purple in colour, and in other respects differ from those of Ordovician age in general appearance. They are bent into folds, but not so sharply and evenly as those of Bendigo. Quartz veins are less frequent than in the Ordovician rocks, and auriferous quartz reefs are generally associated with dioritic dykes, and are often exceptionally rich, as at Wood's Point, Walhalla, etc. Copper ore, associated with platinum, is found in a dioritic dyke at the Thomson R., near Walhalla. The goldfields, however, are generally less extensive than those in the older rocks.

Limestones occur in lenticular patches of considerable extent in the upper part of the Silurian series at Lilydale, near Mansfield, Mitta Mitta, Limestone Creek, etc. Lilydale supplies Melbourne with large quantities of lime.

(e) *Silurian Fossils.* Some of the characteristic fossils are given below:—Upper series (Yeringian): —*Favosites grandipora, Pleurodictyum megastomum, Chonetes robusta, Strophonella euglyphoides, Leptæna rhomboidalis, Pentamerus australis, Atrypa reticularis, Panenka gippslandica, Conocardium costatum, Cyclonema lilydalensis.* Lower Series (Melbournian): *Urasterella selwyn, Palæaster smythi, Protaster brisignoides, Botryocrinus longibrachiatus, Siphonotreta australis, Chonetes melburnensis, Nucleospira australis, Hyolithes spryi, Cyphaspis spryi, Homalonotus harrisoni, Dalmanites meridianus, Pterygotus australis.*

(f) *Devonian.* The Devonian is divided into Upper, Middle and Lower. The principal mass of Devonian rocks lies between Briagolong and Mansfield. Sandstones, conglomerates, shales and limestones form the series. The sandstones are frequently red or purple and often mottled. The conglomerates are well developed near Mansfield, where they are several hundreds of feet thick, and are not folded. A remarkable feature of the conglomerates is the manner in which the pebbles are impressed into one another near Stockyard Creek, on the Dargo road, E. Gippsland. The Grampian Range, consisting of white, grey, red and purple sandstones, some conglomerate and a little shale with rocks of the Snowy River porphyry type, apparently interbedded at Hall's Gap, probably belongs to the Lower Devonian series, and is therefore too ancient to contain any coal seams.

Considerable areas of limestone of this age occur, the best known being at Buchan. The limestone tract here is 15 miles long and 6 miles wide. Caves have been known in this district for a number of years, and some discovered lately are said to rival the Jenolan Caves in beauty and extent. Valuable marble occurs. At Bindi also a considerable area occurs.

The soil from the sandstones and conglomerates is very poor, but the shales and limestones are covered with a very fertile soil.

(*g*) *Devonian Fossils*. The following are some typical fossils. Upper Devonian :—*Archæopteris howitti*, *Sphenopteris iguanensis*, *Cordaites australis*. Lower Devonian :—*Receptaculites australis*, *Favosites multitabulata*, *F. gotlandica var. moonbiensis*, *Syringopora spelæanus*, *Chonetes australis*, *Spirifer yassensis*, *S. howitti*, *Phragmoceras subtrigonum*, *Asterolepis australis*.

(*h*) *Carboniferous*. The Devonian rocks appear to pass without an unconformity into the Carboniferous series. These beds consist of shales and sandstones of reddish colour, and contain abundant fish and plant remains. They are best known to the north of Mansfield.

(*i*) *Carboniferous Fossils*. Some Carboniferous fossils are *Lepidodendron australe*, *Gyracanthides murrayi*, *Acanthodes australis*, *Eupleurogmus cresswelli*, *Strepsodus decipiens*, *Ctenodus breviceps*, *Elonichthys sweeti*, *E. gibbus*.

(*j*) *Permo-Carboniferous*. The glacial conglomerates at Bacchus Marsh, Derrinal, Springhurst, Wooragee, Loddon Valley, and elsewhere are of very late Carboniferous or perhaps Permian age. The glacial conglomerates consist of pebbles and boulders, some rounded and grooved, and some still fairly angular, set in a fine tough clay matrix. The size of the boulders varies from several tons down to fine gravel. As a rule there is no stratification, but in places the boulder clay shews signs of rough bedding. This series appears to correspond with the Duyka conglomerate of South Africa.

Above the glacial series at Bacchus Marsh are thick bedded sandstones containing *gangamopteris*, *glossopteris*, etc.

The glacial beds yield a soil of good quality for grazing purposes.

(*k*) *Permo-Carboniferous Fossils*. Some characteristic fossils are as follows :—*Tæniopteris sweeti*, *Gangamopteris obliqua*, *G. spatulata*, *G. angustifolia*, *G. cyclopteroides*.

(iv.) *Mesozoic*. So far as is known the Triassic and Cretaceous systems are not represented by any formations in Victoria, but the Jurassic system is of great importance, as it contains black coal measures.

(*a*) *Jurassic*. There are three considerable Jurassic areas exposed—those of South Gippsland, the Cape Otway District, and in the neighbourhood of Merino, in the extreme western part of the State. These three outcrops probably form part of a once continuous belt of similar rocks which is marked in the districts between them by Cainozoic sedimentary and volcanic rocks.

The rocks consist of felspathic sandstones, shales, and mudstones, while conglomerates occur along the coast near Kilcunda. Plant remains are common, and seams of black coal up to four feet thick are being worked in South Gippsland. These rocks are much disturbed and faulted, adding greatly to the difficulties of coal mining. Dykes and sills of basalt, as well as some old volcanic necks of early Cainozoic age penetrate these rocks.

(*b*) *Jurassic Fossils*. Amongst the characteristic fossils are :—*Coniopteris hymenophylloides var. australica*, *Cladophlebis denticulata var. australis*, *Sphenopteris ampla*, *Thinnfeldia odontopteroides*, *T. maccoyi*, *Tæniopteris spatulata* and *vars. daintreei* and *carruthersi*, *Ginkgo robusta*, *Baiera subgracilis*, *Podozamites barklyi*, *Palissya australis*, *Brachyphyllum gippslandicum*, *Unio stirlingi*.

(v.) *Cainozoic*. The Cainozoic series, as represented in Victoria, is as follows :—

(*a*) *Eocene*. Beds of marls, clays, sandstones, and limestone of Eocene age are exposed along the littoral of Port Phillip at Geelong, Mornington, etc., and inland at Royal Park and along the Moorabool Valley. The limestone is used for building purposes, both as lime and as building stone, and for filters, and the marl at Mornington would form a valuable fertiliser for poor sandy soil.

(*b*) *Miocene.* Miocene clays, sands, conglomerates, etc., occur in the Moorabool Valley, near Morrison's, Melton, Altona Bay, Pitfield, in the La Trobe Valley, Cobungra, and at Feathertop, under the basalt of the Dargo high plains, etc. The brown coal beds are sometimes of enormous thickness. At Morwell a bore 1000 feet deep passed through 888 feet of brown coal. Many of the clays are valuable for pottery purposes, and they occur in very large quantities.

(*c*) *Pliocene.* The Pliocene period is represented in Victoria by sand dune formations and impure limestones near the coast, and by silt, sand, clay and gravel inland.

On the goldfields there are two distinct gravel formations, known as the Older and Newer Pliocene. The Older Pliocene gravels are generally composed of well-rounded quartz pebbles, bound together by clay or ferruginous cementing material. They cap the hilltops or occur in deep leads at levels of 300 or 400 feet below the present surface. They are frequently highly auriferous. The old deep leads were the drifts in ancient river valleys, and have since been covered to great depths by more modern silts, or by flows of basalt. Valuable deposits of clay occur of this age.

The Newer Pliocene of the goldfields consists of some highly rounded pebbles derived from the Older Pliocene mixed with sub-angular and angular pebbles, bound together by red, purple and grey mottled clays and drift material. The gravels are often highly auriferous. The Newer Pliocene beds are found at a lower level than the older gravels which cap the hilltops.

Sands which may be of Pliocene age cover a large area in the Mallee district. Soil from the Pliocene rocks is generally of poor quality.

(*d*) *Post Pliocene.* River terraces composed of red loam are found in the principal valleys as at Wangaratta, Carisbrook, etc. They contain Diprotodon remains indicating a fauna now extinct. These beds are most suitable for brickmaking, and yield a soil of good quality.

(*e*) *Pleistocene Fossils:—Ostrea angasi, Mytilus planulatus, Tellina deltoidalis, Natica conica, Vermetus novæhollandiæ, Pagrus unicolor, Sthenurus atlas, Macropus titan, Diprotodon longiceps, Phascolomys pliocenus, Sarcophilus ursinus, Canis dingo.*

(*f* *Recent.* Under this heading come the present river drifts, the shifting sand dunes along parts of the coast, the deposits filling swamps such as Koo-Wee-Rup and Carrum, the surface limestone found over wide areas in the Mallee, and the surface in process of formation. The soils range from the most fertile to the most barren.

(*g*) *Fossils.* Mr. Chapman[1] makes the following note:—"The Tertiaries are here grouped under their several local horizons. In the present condition of our knowledge of the Tertiary stratigraphy of the State, about the succession of which there are yet varieties of opinion, it is impracticable to exactly indicate the equivalence of the strata to the various series defined in European areas."

Some of the characteristic Tertiary fossils in descending order are:—

KALIMNAN.[2]

Balcombe Bay Beds—Spondylostrobus smythi, Eucalyptus pluti, Plesiocapparis prisca, Bathyactis beaumariensis, Glycimeris halli, Trigonia howitti, Zenatiopsis angustata, Tylospira coronata, Voluta masoni, Cancellaria wannonensis, Cestracion cainozoicus, Oxyrrhina hastalis.

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1. F. Chapman, Esquire, A.L.S., F.R.M.S., Palæontologist to the National Museum of Victoria, who has supplied the lists of typical fossils.
2. *These are the sub-divisions of the Cainozic accepted by Mr. Chapman.*

JANJUKIAN.

Coprosmaephyllum ovatum, Cyclammina complanata, Deltocyathus subviola, Graphularia senescens, Cassidulus australiae, Terebratulina catinuliformis, Limopsis insolita, Spondylus gaederopoides, Spiruliroatra curta, Carcharodon auriculatus, Squalodon wilkinsoni, Ziphius geelongensis.

BALCOMBIAN.

Cinnamomum polymorphoides, Laurus werribeensis, Operculina complanata, Plectroninia halli, Plachotrochus deltoideus, Magellania grandis, Arca celleporacea, Crassatellites dennanti, Chama lamellifera, Cypraea eximia, Galeocerdo davisi, Lamna apiculata.

(vi.) *Plutonic.* A feature in the distribution of the granitic rocks is the manner in which the outcrops occur distributed over the whole State, except where the surface consists of Tertiary or Jurassic rocks which conceal the Plutonics. There are many varieties of the granitic rocks, such as granites, granodiorites, syenites, hornblende diorites, gabbros, etc. Auriferous quartz veins occur in the granodiorite rocks at Glen Wills, Mt. William and Warburton ; tin lodes at Beechworth, Cudgewa and Koetong ; copper at the Snowy River and in other parts of E. Gippsland ; galena at Mt. Deddick and at Pine Mountain, Upper Murray. The soil derived from granitic rocks is generally of poor quality. The granodiorites yield a somewhat better soil than the other varieties.

(vii.) *Volcanic.* (*a*) *Diabases.* Interbedded lava flows, ash beds and agglomerates occur in the Heathcotian, which, as already mentioned, is a formation older than the Ordovician. These rocks are well represented at Heathcote and in the Mt. Camel Range, at the Dog Rocks near Batesford, Green Hill near Geelong, etc. Soil of moderate quality.

(*b*) *Snowy River Porphyries.* These acid volcanic rocks of Lower Devonian age (?) are widely distributed in Eastern Gippsland, along the course of the Snowy River and in the Mitta Mitta Valley. With the lavas there is a great thickness of ash and agglomerate, which contain lodes of gold, copper, and silver-lead ore. Extremely beautiful porphyries occur in these rocks. The soil is poor.

(*c*) *Dacites.* The age of the Dacite series is not settled. They form the mountains at Healesville and Warburton, Dandenong Range, Mt. Macedon, and part of the Strathbogie Ranges. No metallic lodes have been found associated with these rocks. The soil varies from a rich loam to a poor siliceous sand.

(*d*) *Basalts.* The oldest basalt known in the State is that described by Dr. Howitt as interbedded with the Upper Devonian at Snowy Bluff, but the important basalts are of Tertiary age.

The Older Basalt (Eocene to Pliocene) is found at Dargo High Plains, Gelantipy, Warragul, Narracan, the Mornington Peninsula, Phillip and French Islands, etc. The soil is fertile, but the area occupied is insignificant when compared with the area covered by the Newer Basalts.

The Newer Basalts (Pliocene to Recent) extend to the north-west and west of Melbourne for almost 200 miles. This volcanic series forms vast plains of lava flows and ashes with numerous scattered scoria cones in all stages of preservation. Excellent building stone and good road metal is furnished by these volcanic rocks. The soil varies from a poor loam to dark brown and black clayey soils of marvellous fertility.

4. **Geology of Queensland.**[1]—From a geological point of view Queensland may be divided into two great parts, occupying nearly equal areas, but possessing very different physical features. One of these extends along the eastern coast, from the New South

1. This article is slightly condensed from one by W. H. Rands, Esquire, A.R.S.M., F.G.S., Government Geologist of Queensland.

Wales border northwards to the 12th parallel of latitude, has an average width of about 200 miles from east to west, and is well watered and timbered. To this division also belongs an area in the north-west portion of the State, viz., in the Burke district, extending from the extreme north-west southwards to Cloncurry and Boulia. The loftiest mountain ranges occur in this division, the remnants of what was once a high tableland, the highest peak, Bellenden Ker, attaining an elevation of 5150 feet.

This region consists of stratified rocks of different ages from the oldest palæozoic—the exact age of older rocks has not yet been determined—up to those of recent origin. There are also large areas of granites, porphyries partly of igneous and partly of metamorphic origin, as well as other intrusive and interbedded igneous rocks. It is in this division that most of the mineral wealth of the State exists.

The other large division, known as the Western Interior, consists almost entirely of the Lower Cretaceous rocks, overlaid unconformably in places by the Desert Sandstone, which is of Upper Cretaceous Age.

This division, locally known as the Rolling Downs Formation, presents a vast area, in parts of almost treeless plains, with here and there clumps of "gidya" scrub.

The rainfall over this division, more especially in the south-west, is small. The river beds are generally dry. The want of water limits the use of some of the very best pastoral land in the State, though this difficulty has been partially overcome by the tapping of the supplies of artesian water contained in the Lower Cretaceous Beds.

The rivers to the north of the high open downs, in latitude about 21° 50′ S., flow in a northerly direction into the Gulf of Carpentaria, while south of this they flow in a southerly, or south-westerly direction, into New South Wales.

(i.) *Geological Formations of Queensland.* The following table indicates the geological formations so far known as occurring in Queensland:—

QUATERNARY AND CAINOZOIC ...	Recent Alluvia, Raised Beaches, Post-Tertiary or Tertiary Alluvia, and Bone-Drifts.
MESOZOIC	Upper Cretaceous—Desert Sandstone. Lower Cretaceous—Rolling Downs Formation; Blythesdale Braystone. Trias-Jura System—Upper Ipswich Formation; Lower Burrum Formation.
PALÆOZOIC	Permo-Carboniferous—Upper Bowen Formation; Middle Bowen Formation; Lower Bowen Formation; Star Formation; Gympie Formation. Devonian—Middle Devonian Formation. Silurian—Silurian Formation. Age undetermined—Slates, Schists, and Quartzites, etc.

(ii.) *Plutonic and Metamorphic Rocks.* Large areas of granites, syenites, porphyries of both plutonic and metamorphic origin and of different ages, extend from the south to the north of the State.

In these a number of mineral areas are included, viz.:—The Charters Towers, the Croydon, Etheridge, Eidsvold, Normanby, Jimma goldfields; the Ravenswood gold and silver fields; Kangaroo Hills and Running Creek silver and tin fields; the Herberton and Annan, Bloomfield, and Stanthorpe tinfields; and the Mount Perry copper field.

(iii.) *Metamorphic Rocks.* These, embracing the slates, schists, etc., of undetermined age, are all older than the Burdekin Beds—Middle Devonian—and are all more or less metamorphosed. They consist of metamorphic granites, quartzites, slates, schists, gneisses, and shales. No fossils have up to the present been discovered in them, and their exact age has not yet been ascertained.

The principal mining areas in connection with these rocks are:—The McKinlay, Cape River, Gilbert and Woolgar, Coen, Normanby, Clermont, and Peak Downs goldfields; and the Peak Downs copper field.

(iv.) *Silurian.* A large region in the north-west part of the State, formerly included in the slates and schists, etc., of undetermined age, were transferred to the Silurian, the evidence as to the age of the rocks being determined by Mr. R. Etheridge, junr., from certain fossils found near the Cairns Range.[1]

The area mapped as Silurian extends from the south of Boulia to the extreme north-west, and from 20 miles east of Cloncurry to the Western boundary of the State, but its boundary has not yet been accurately mapped.[2]

The principal mining areas are the Cloncurry, McKinlay, and Leichhardt goldfields, the Cloncurry copper fields, and the Lawn Hills silver field. There are also the rich ironstone deposits of Mount Leviathan, and of other hills in the neighbourhood of Cloncurry.

(v.) *Middle Devonian* (Burdekin Formation). Rocks containing characteristic fossils of the Middle Devonian occur in various parts of the State. The principal area, and the one from which the formation takes its name, is on the Upper Burdekin, including the Fanning River, Burdekin Downs, and Broken River. Rocks of this age also occur at Chillagoe; Reid's Gap; on the Townsville-Charters Towers Railway; south of Clermont; at Raglan; and in the neighbourhood of Olsen's Caves, north of Rockhampton.

A doubtful area is shewn on the last addition of the State map in the extreme north-west, in the neighbourhood of Camooweal.

The fossils occur in limestones, and consist almost entirely of corals, with a few Brachiopoda, and one Cephalopod. The most characteristic fossils are *Heliolites porosa*, *Pachypora meridionalis*, *Aulopóra repens*, *Stromatopora*, and *Cystiphyllum*.

The Argentine silver field occurs in a series of slates and schists, etc., supposed to belong to this formation.

(vi.) *The Permo-Carboniferous System.* The greater portion of the stratified rocks of the eastern portion of Queensland are included in this system.

The system, as hitherto classified, includes five formations, beginning from the oldest, viz.: (1) Gympie Formation, (2) Star Formation, (3) Lower Bowen Formation, (4) Middle Bowen Formation, (5) Upper Bowen Formation.

A reclassification of these rocks may be found necessary; the following has been suggested:—

GYMPIE ...	... Marine Series.
(?) ...	... Basic and Acidic Intrusions.
LOWER BOWEN ...	... Lower Marine and Volcanic Series; Lower Fresh-water Series; Upper Marine Series; Upper Fresh-water Series.
UPPER BOWEN ...	... Marine Series; Fresh-water Series; Old Alluvial Deposits.

(*a*) *The Gympie Formation*, named after the type district (the Gympie goldfield), occupies large areas in the south-eastern, central, and north-eastern parts of the State, and consists chiefly of sandstones, grits, conglomerates, indurated shales, and limestones. These, in parts, have undergone considerable alteration. Bedded volcanic rocks are numerous, especially in the type district, as are also intrusive rocks. The strata generally dip at high angles of inclination.

This contains a very scant flora, represented by Calamites, Lepidodendron: but it has produced the largest fauna of any formation in Queensland, over 120 species having been described. The following genera are peculiar to it, viz.:—

1. These were identified as follows:—(1) Orthoceratites, sp. ind.; (2) Actinoceras (beaded siphuncle), sp. ind.; (3) Univalve and bivalve (casts and impressions). These are interesting, as the first Silurian fossils found in Queensland.

2. See the Geological Map of Queensland of 1899.

Protozoa.—Lasiocladia.
Actinozoa.—Zaphrentis, Cyathophyllum, Cladochonus, Monticulipora.
Blastoidea.—Mesoblatus, Granatocrinus, Tricœlocrinus.
Echinoidea.—Archæocidaris.
Crustacea.—Griffithides.
Polyzoa.— Glauconome, Rhombopora, Myriolithes.
Brachiopoda.—Martinia, Athyris, Lingula.
Pelecypoda.— Pterinopecten, Mytilops, Parallelodon, Nucula, Pleurophorus, Astartella, Cypricardella, Eurydesma, Conocardium, Edmondia, Sanguinolites.
Gasteropoda.—Loxonema, Euomphalus, Pleurotomaria, Yvania, Luciella, Murchisonia, Bucania.
Pteropoda.—Conularia.
Cephalopoda.—Nautilus, Gyroceras.
Pisces.—Deltodus ?

Several gold and other mineral fields occur in the Gympie formation, amongst which may be mentioned:—The Gympie goldfield, Cania, Calliope, Norton, and other goldfields in the Gladstone district; the goldfields of the Rockhampton district; the Warwick goldfields; Paradise, Hodgkinson, Mulgrave, and Palmer goldfields. Copper deposits at Glassford Creek, Gigoomgan, Gooroomgan, and Mount Coora; some mercury deposits at Kilkivan; and the Neerdie antimony mine.

(*b*) *The Star Formation.* The palæontological evidence for separating these beds from the Gympie Series is slight. They contain nineteen species peculiar to themselves, and twelve species common to both, but are, however, less highly inclined than the Gympie Beds, and have been less disturbed and altered.

They are best developed at the following places:—Near the junction of the Great and Little Star Rivers, from which they take their name; near Dotswood, Keelbottom Creek; in the neighbourhood of Harvest Home, Lornesleigh, and Mount McConnell Stations (near the latter the nearly complete remains of a fish of the genus Palæoniscus was found); and at Drummond's Range, where numerous scales and teeth of fish occur.

The flora includes species of Calamites, Asterocalamites, Lepidodendron. Cyclostigma, Stigmaria, and Cordaites. The fauna is comparatively small when compared with that of the Gympie Beds, and includes the following genera:—

Crinoidea.—Actinocrinus.
Crustacea.—Beyrichia, Phillipsia.
Polyzoa.—Fenestella.
Brachiopoda.—Spirifera, Spiriferina, Retzia, Rhynchonella, Orthis, Strophomena, Chonetes.
Pelecypoda.—Entolium, Euchondria, Nuculana.
Gasteropoda.—Naticopsis, Porcellia.
Cephalopoda.—Orthoceras.
Pisces.—Palæoniscus.

(*c*) *The Lower Bowen Formation.* This formation consists of a series of white and yellow sandstones, with beds of conglomerates, containing pebbles of quartzite and porphyry, derived from the metamorphic rocks in the vicinity: the lowest beds, seen near the heads of Pelican Creek, south-west of Bowen, consisting of volcanic agglomerates. It dips under the Trappean rocks of Toussaint, Mount Dinlin, and Mount Macedon.

In another area, north of Mackay, the beds have undergone considerable alteration. So far no fossiliferous remains have been found therein.

(*d*) *The Middle Bowen Formation.* This series overlies the last without any marked unconformity. It consists of alternate sandstones, blue and grey shales, and impure arenaceous ironstones, and extends from the type district on the Bowen River across the central railway between the Emerald and Duaringa, and for about 120 miles farther south up to the Dawson and Comet Rivers. The mapping out of these beds in detail on both sides of the central railway suggested the need for an alteration in the classification previously referred to.

Seams of coal have been discovered therein, both north and south of the railway line, one thirty miles south of Duaringa being nine feet thick of perhaps the best coal for steam purposes in the State; it is anthracitic, containing almost 87 per cent. of fixed carbon. Several seams of coal—most of them of a burnt or coked nature—occur in the type district; this is due to the intrusion of sheets of trap rock.

Although it contains a land flora in places the Middle Bowen is mainly marine. The flora include species of *Glossopteris* (which is very common), *Sphenopteris*, and a species of *Conifer*.

The fauna consists of over fifty described species, of which the most characteristic fossils are:—*Strophalosia clarkei*, Eth.; *Strophalosia gerardi*, King; and *Derbyia senilis*, Phill., which, with species of *Productus*, *Spirifera*, and *Martinia*, are very common.

(*e*) *The Upper Bowen Formation*. The Upper Bowen Beds are chiefly fresh water, and contain but very small flora and fauna. The flora includes *Phyllotheca australis*, *Sphenopteris lobifolia*, *S. flexuosa*, *S. crebra*, *Glossopteris browniana*, *G. linearis*, and a species of a *Conifer*. The fauna includes *Derbyia senilis*, *Productus brachythærus*, and a species of *Goniatites*.

The rocks have a low angle of dip in the type district, and cover a large area to the south of these creeks. They contain numerous coal seams, including the Macarthur, Daintree, and Havilah seams, but most have been destroyed by the intrusion of sheets of dolerite.

Beds of this formation occur west of Laura, on the Cooktown railway, on the Little River coalfield; at Hamilton, about twenty miles west of Cooktown; at Stewart's Creek, near Townsville, also further south near Mackay; and at Blair Athol, ten miles north-west of Clermont. Blair Athol is the only place where the coal seams of this formation are actually being worked; the coal is one of the best steam coals worked in the State.

(vii.) *Lower Trias-Jura* (the Burrum Formation). The Burrum Formation, the lowest member of Mesozoic rocks, extends along the coast from a point about 50 miles north of Bundaberg to south of Noosa Heads, and occupies an area of 3000 square miles.

Over the greater portion of this area the coal measures are covered unconformably with sandstones, clays, and conglomerates of a more recent age, a fact to which is attributable the flat and barren nature of the country. The overlying rocks, 20 to 50 feet in thickness, lie horizontally or nearly so. Their exact age has not been determined, as no fossils have been found in them.

This formation consists of grey and brown sandstones, conglomerates, and grey and black shales, etc. The flora and fauna are both very scant. The former includes:—*Sphenopteris flabellifolia*, var. *erecta*, T. Woods; *Trichomanites laxum*, T. Woods; *Thinnfeldia media*, T. Woods; *Tæniopteris daintreei*, McCoy; *Alethopteris australis*, Morris; *Podozamites kidstoni*, Eth. fil.; *Otozamites*, sp. ind., and *Baiera bidens*, T. Woods. The fauna is represented by *Corbicula burrumensis*, Eth. fil., and *Rocellaria terra regina*, Eth. fil.

Seams of coal are known to occur in these measures in Littabella Creek, north of Bundaberg, to near Noosa, in the southern portion of the field, and have been worked near the Burrum River in the neighbourhood of the townships of Howard and Torbanlea, situated about 20 and 15 miles respectively north and north-west of Maryborough.

In the Burrum River, just above the railway bridge, five seams of coal of payable thickness can be seen cropping out in the bank within a distance of half a mile, with a regular dip to the north-east at about 12 degrees.

(viii.) *Upper Trias-Jura* (the Ipswich Formation). The Ipswich Coal Measures cover an area of about 12,000 square miles in the south-eastern portion of the State, a small area occurring in the neighbourhood of Stanwell and Wycarbah, in the Rockhampton district; and another on Callide Creek, south-west of Gladstone, where there is one seam of over 30 feet in thickness of solid coal.

The rocks consist of the usual alternations of sandstones, conglomerates and shales, etc. In the neighbourhood of Brisbane the base of the measures is a volcanic ash, consisting of a felspathic matrix with blebs of quartz, and angular pebbles of schist and quartz. This stone is largely used for building purposes, as are also certain of the sandstones and freestones from this formation.

On the western portion of this area at Gowrie, Jimbour, and Clifton, the coal measures are on a higher horizon to those in the Brisbane and Ipswich district, from which they are separated by a thick mass of basalt.

The flora of the Ipswich Formation contains over eighty known species, five of which are common to the Burrum beds.

The fauna is represented by four species only, viz.:—*Estheria mangalensis*, Jones; *Mesostigmodera typica*, Eth. fil. and Oliff; *Unio ipsviciensis*, Eth. fil.; and *Unio eyrensis*.

Several seams occur in the Albert and Logan district, south of Brisbane, and thin coal has been met with close to Brisbane, but no mines have been opened up in either of these localities.

(ix.) *Lower Cretaceous Formation* (the Rolling Downs Formation). The strata of this formation, covering nearly the whole of the western interior, have a very great sameness over this immense area—equal to over half of the whole State—and consist of shales, sandstones, conglomerates, and thin limestones. Thin beds of coal have been met with in boring.

A very porous bed of sandstone—the Blythesdale Braystone—has been traced from the neighbourhood of Texas, on the southern border of the State, to Normanton, in the north of the Gulf of Carpentaria. This is the chief intake rock of the series from which the supply of artesian water is obtained.

The volume of flow of the many rivers that run across or along this sandstone greatly diminishes, shewing that it has absorbed the water. The efflux of the numerous bores, however, is very small when compared with the amount of water taken in by this rock and other porous beds that occur. It has been supposed that the water finds an outlet to the sea at the Great Australian Bight and at the Gulf of Carpentaria.

The Rolling Downs Formation has been classified under the general head of Lower Cretaceous, but it contains amongst its numerous fauna forms allied to the Oolite.

The fauna is represented by over 120 species. Ammonites and Belemnites make their appearance. Among the fish remains have been found the following species:—*Lamna daviesii*, Eth. fil.; *Lamna appendiculata*, Agassiz; a species of *Aspidorhynchus*, Agassiz; and *Belonostomus sweeti*, Eth. fil. and A. S. Woods. There are also the following reptilian remains:—*Notochelone costata*, Owen; *Ichthyosaurus australis*, McCoy; *Ichthyosaurus marathonensis*, Eth. fil.; *Plesiosaurus macrospondylus*, McCoy; *Plesiosaurus sutherlandi*, McCoy.

(x.) *Upper Cretaceous* (Desert Sandstone Formation). This formation at one time covered the greater portion of Queensland, but the work of denudation has left only isolated patches, or outliers, which overlie unconformably the older rocks. Some of these patches are of large extent, especially in the western districts, where they overlie and act as feeders to the Lower Cretaceous water-bearing beds.

The base of the Desert Sandstone, from 1000 to 1800 feet above the sea-level in the southern and central portions of the State, at Cape York Peninsula is nearly at that level.

The beds are always horizontal, or nearly so, and consist usually of very coarse sandstones (often false-bedded), coarse conglomerates, shales, and magnesite shales.

A series of rocks in the neighbourhood of Maryborough, overlying the Burrum Coal Measures, against which they have been faulted, have been included in this formation. They have produced a large number of fossils, some of which are allied to those from the Desert Sandstone at Croydon. Except at these places, the formation is almost barren of fossiliferous remains.

Glossopteris was discovered in rocks of this age at Betts Creek, near the Cape River goldfield, but had not before been discovered in Australia later than in the Permo-Carboniferous. *Glossopteris* was also found in the tableland between the Mitchell and the Walsh Rivers, and was consequently ascribed to the Carboniferous, though these rocks have since been found to be Upper Cretaceous. The genus makes its reappearance, therefore, in this formation, as it has not been detected in the formations intervening between this and the Permo-Carboniferous.

The fauna and flora are represented by thirty-five species, of which only the following eight species have been found outside the Maryborough rocks, and all of these, except the *Glossopteris*, are from Croydon :—*Didymosorus (?) gleichenioides*, Oldham and Morr.; *Glossopteris browniana*, Brong. ; *Rhynchonella croydonensis*, sp. nov. ; *Ostrea*, sp. ind. ; *Placuna*, sp. ind. ; *Maccoyella barklyii*, var. *mariæburiensis*, Eth. fil. ; *Teredo*, sp. ind.; *Siphonaria samwelli*, sp. nov.

The only mineral of commercial value from these beds is the opal, for which there is now a considerable demand. Its chief sources are Opalton, Mayne River, Opal Range, Jundah, Duck Creek, Nickaville, and Listowel Downs.

(xi.) *Tertiary.* The Tertiary deposits are very poorly represented in Queensland—in fact, with the exception of a few alluvial drifts and some raised beaches, no sedimentary deposits of this age are known.

There was undoubtedly great volcanic activity at this period, as is evidenced in many parts of the State by the outflows of basalt capping the Desert Sandstone.

(xii.) *Post-Tertiary and Recent.* This period is represented by bone-drifts on the Darling Downs ; Peak Downs ; at Maryvale Creek ; and along the Burdekin River, etc. They have furnished numerous remains of living and extinct marsupials, such as *Diprotodon australis*, *Macropus titan*, *Macropus ajax*, and other species of the same genus ; *Thylacoleo ;* several species of *Phascolomys*, and *Nototherium*, etc. ; a struthious bird *Dromornis ; Dinornis*, and the remains of reptiles and fishes.

The deposits in the Chillagoe Caves of North Queensland, and in the Olsen and Johansen Caves near Rockhampton, have also furnished a few bones, and may be expected to be a rich source of organic remains, when they come to be thoroughly explored.

5. **Geology of South Australia.**[1]—In order to elucidate this indication of the principal geological formations of the State of South Australia, a short description of its physical geography is necessary.

A main range extends from Cape Jervis in the south, the opposite point of the mainland to Kangaroo Island, to beyond Hergott Springs in the north, a distance of about 400 miles: branching from about 150 miles north of Adelaide to the New South Wales border in the vicinity of the Barrier Ranges, and from Beltana north-eastward to Mount Babbage. This area includes the Mount Lofty, Barossa, Flinders, Mount Nor' West and Willouran Ranges, and also smaller ones. The highest points are: Mount Lofty, 2327 feet ; Mount Brown, near Port Augusta, 3200 feet ; St. Mary's Peak, Wilpena, 3900 feet ; and Benbonyathe Hill, near the Illinawortina Pound, 3476 feet.

The Tomkinson, Mann, and Musgrave Ranges extend in the north-west corner from the West Australian boundary eastward for over three degrees of longitude along and south of the 26th parallel of south latitude, the northern boundary of the State. The Gawler Ranges run from near Port Augusta westward for about 120 miles. Northward of these are the Warburton Ranges, isolated and of comparatively low elevation. Ranges of similar character are the Peake and Denison, west of Lake Eyre ; and there are also detached areas in the vicinity of Port Lincoln and Franklin Harbour, on Eyre Peninsula. The remainder of the State consists of plain and undulating country, with occasional isolated low peaks.

The lakes, mainly large expanses of mud, are numerous and extensive, and occupy low-lying portions of the plain country ; the principal ones are Lakes Eyre, North and South, Torrens, Gairdner, Frome and Blanche.

The Murray is the largest river. It enters the eastern boundary of the State in latitude 34°, runs eastward to Morgan, thence southward to its mouth at Encounter Bay, previously widening out into Lakes Alexandrina and Albert ; this is the only navigable river in South Australia. The drainage from the eastern watershed of the main range, as far north as the Burra, runs into the Murray, from the western as far north as Port Augusta, into Gulfs St. Vincent and Spencer ; further northward the eastern drainage is

1. This article is contributed by H. Y. L. Brown, Esquire, F.G.S., Government Geologist of South Australia.

on to plains and into Lake Frome, and the western into Lake Torrens; north of latitude 30° drainage from all sides is into Lake Eyre, the principal rivers being the Cooper and Diamantina entering from Queensland, the Finke from the MacDonnell Ranges, Northern Territory, the Alberga and the Hamilton from the Musgrave Ranges, and the Neales and others from the westward. From the Musgrave Ranges southward to the Great Australian Bight, and the west coast of Eyre Peninsula, there are no lines of drainage of any importance on the surface.

The coast-line presents roughly a sweep north-westward from Cape Northumberland in latitude 38° S., to Eucla latitude 31° 30′ S., crossing 12 degrees of longitude (129° to 141°), deeply indented by two gulfs, St. Vincent's and Spencer's. Kangaroo Island, immediately south of St. Vincent's Gulf, is the largest island of the State, and there are numerous smaller islands, grouped and separate, in Spencer's Gulf, and on the west coast as far as Fowler's Bay.

From Eucla to the head of the Great Australian Bight, the coast-line consists of continuous cliffs from 200 to 300 feet high, forming the edge of the Nullarbor Plain plateau.

The various geological formations will be referred to in ascending order.

(i.) *Archæan* (Metalliferous Rocks). Granite, gneiss, and crystalline metamorphic, hornblendic, micaceous and argillaceous rocks are found at several places, but to a limited extent, to underlie rocks containing Cambrian fossils; and in other places there are considerable exposures of granitic and gneissic rock containing granitic dykes of later age, which may also be Pre-Cambrian; these constitute the lower rock systems and may be classed as Archæan. Chief localities: Southern portion of Yorke's Peninsula, North-East, north end of Main Range, Musgrave Range, etc.

(ii.) *Pre-Cambrian and Cambrian* (Metalliferous Rocks). The Main Ranges from Cape Jervis to Mt. Babbage, the Ranges at Port Lincoln and Franklin Harbour, Kangaroo Island, the North-eastern (Olary) Ranges, Mt. North-west Ranges, the Peake and Dennison Ranges (near Lake Eyre), and isolated areas are composed of highly-contorted, faulted, cleaved, jointed and metamorphosed beds of micaceous, hornblendic and quartzose schists, sandstones, quartzites, argillites, clay slates, conglomerates, crystalline limestones and dolomites intruded into and intersected in places by igneous rocks consisting of granites, diorite, dolerite, gabbro, felspar, porphyry, felsite, etc. The Gawler Ranges are composed of granite and felspar-porphyry, the latter predominating, the Musgrave Ranges of granite, metamorphic and eruptive, and altered sedimentary rocks. Cambrian rocks containing fossils of undoubted Cambrian age, have been found in dolomitic limestone beds at Normanville and Sellick's Hill, south of Adelaide, near Ardrossan, Yorke's Peninsula, near Gordon, Belton, Wirrealpa, Ajax Mine, and Ediacara in the far north, and east of Hawker. These beds occur in connection with those just mentioned, but owing to the intense plication, varying thickness, faulting and non-persistence of individual beds and metamorphism of the whole series, their exact stratigraphic relationship can only be determined by exhaustive geological survey and mapping.

(a) *Pre-Cambrian and Cambrian Fossils.* These are as follows, viz.:—*Ethmophyllum hindei*, *Coscinocyathus tatei*, *Microdiscus subsagittatus*, *Ptychoparia australis*, *Orthisina compta*, *Platyceras etheridgei*, *Stenotheca rugosa*, *Hyolithes communis*, *Protopharetra (?) scoulari*, *Olenellus pritchardi*, *Dolichometropis tatei*, *P. howchini*, *Ambonychia macroptera*, *Ophileta sublangulata*, *Salterella planoconvexa*, *H. conularioides*.

(iii.) *Ordovician.* Beds of quartzite, sandstone, grit, shale, and conglomerate dipping at low angles and often horizontal occur on Kangaroo Island, in the neighbourhood of Port Augusta, along the western side of Lake Torrens, and on the Alberga River. No fossils have been found in them, but from the positions they occupy and their resemblance to the Ordovician fossiliferous rocks found south of the MacDonnell Ranges, they are probably of that age.

(iv.) *Jurassic.* This is represented by argillaceous, carbonaceous, and bituminous shale with thin bands of sandstone, limestone, ironstone, pyrites, etc., containing seams of coal. The best defined outcrop of this formation is at Leigh Creek, where a basin has been proved by boring to have an extreme depth of about 2000 feet of strata containing Jurassic fossils. In one bore at from 1496 to 1544 feet, over 47 feet of brown coal was passed through in one continuous bed, and small seams at intervals for 300 or 400 feet deeper. Characteristic fossils of the same age have been discovered at Ooroowillannie Swamp, near Kuntha Hill on Cooper's Creek, and bituminous shale and coal similar to that of Leigh Creek at Lake Phillipson and other places in bores put down for artesian water. There is no distinct line of demarcation between this and the overlying Lower Cretaceous formation. It is probable that the sandstone, gravel, and conglomerate in which this water occurs is of Jurassic age.

(a) *Fossils.* The fossils observed are :—*Alethopteris australis, Macrotæniopteris winamattæ, Oleandridum (?) fluctuans, Podoxamites lanceolatus, Thinnfeldia odontopteroides, T. media, Unio eyrensis.*

(v.) *Lower Cretaceous.* These consist of gypseous clays, marls, argillaceous shales, and sandstones, with thin bands of limestone, ironstone, pyrites, etc., and sometimes thin seams of brown coal resting on sandstone and gravel conglomerate beds. This formation, with or without the underlying Jurassic beds, fills the vast artesian basin of which Lake Eyre is approximately the centre; from the north-east corner of the State it is continuous westward along the Queensland border and to slightly beyond the 134th meridian, and southward along the boundaries of Queensland and New South Wales to latitude 30° S. Westward of Lake Eyre, its boundary has not yet been determined, but probably does not extend very far in that direction; it is bounded northward and southward by granite and other primary rocks.

The most western bore, viz., that at Lake Phillipson, has passed through a shale formation down to 3131 feet. The depth to which bores have been sunk in this area, and artesian water obtained, varies from a few feet in the vicinity of the outcrops of primary rocks to 4850 feet in that portion of the basin extending northwards towards the Queensland border.

(a) *Fossils.* The fossils observed are :—*Lingula subovalis, Pecten socialis, Pseudavicula australis, P. anomala, Maccoyella barklyi, M. corbiensis, Lima randsi, Pinna australis, Mytilus rugocostatus, M. inflatus, M. linguloides, Nucula quadrata, Cytherea clarkei, C. woodwardiana, Leda elongata, Mya maccoyi, Natica variabilis, Cinulia hochstetteri, Belemites australis, B. canhami, Crioceras australe,* and others.

(vi.) *Mesozoic.* This is represented by argillaceous and arenaceous shales, grits, sandstones, quartzose sandstone, gravel, and conglomerate, with limestone and concretionary clay ironstone. The deposit, which is horizontal and undulatory, contains scattered pebbles and boulders of granite, quartzite, sandstone, etc. Some of these boulders are of great size, and denudation has led to their being scattered over the surface to a considerable extent. Bores have been sunk through the deposit to ascertain whether it contained coal, as from its general appearance and resemblance to carbonaceous rocks of the Cape Otway district, Victoria, which contain small seams of coal and are of Mesozoic age, it was thought that this might be the case. It may be noted that the Cape Otway beds also contain beds of pebble conglomerate, the pebbles consisting of granite, syenite, mica-schist, etc. The deposit is undoubtedly a glacial one. The greatest thickness proved by boring through these beds was 964 feet, at which depth clay slate of primary age was bottomed on. The area occupied by the deposit is considerable; the main body stretches across from Victor Harbour to Yankalilla, a distance of about twenty miles; it is of irregular shape, having a width in places of five miles, and lies in a trough between high ranges; its boundaries have not yet been completely defined, and it probably underlies a portion of the Miocene Tertiary lying north and north-westward of Crozier's Hill and other places in the hundreds of Encounter Bay, Goolwa, and Waitpinga. Between Yankalilla and Second Valley, and at Cape Jervis there are beds of clay and boulder drift which may be of similar age; and these may, however, have been reconstructed from them or deposited during Miocene times. On Kangaroo Island, in the hundred of Menzies, there is a similar deposit, which consists of false-bedded horizontal and slightly-dipping beds of sandstone and grit, with pebble conglomerate layers on shale and sandy clay, containing concretionary masses of brown iron ore and ferruginous sandstone with pebbles, and overlaid unconformably by basalt; it appears to be an outlying area of the Yankalilla and Encounter Bay beds. No fossils have been found at any of these localities, but from the similarity of these beds to those of the Cape Otway district they may be provisionally classed as Mesozoic.

(vii.) *Lower Tertiary or Upper Cretaceous.* Chiefly in the north-eastern portion of the State there are large areas of stony downs and table-hill country where sheets and isolated cappings, as thin beds of sandstone, quartzite, conglomerate, jasper rock, porcelainised shale, etc., etc., overlie both the Lower Cretaceous and older rock formation, which are either of Lower Tertiary or Upper Cretaceous age. The beds are intermittent in character, and are scattered over an area extending from the end of the Musgrave Ranges eastward to the Queensland border, and southward to Lakes Frome, Torrens, and Gairdner, and westward towards the West Australian border, in which direction they occur as small and widely-separated exposures.

(*a*) *Principal Fossils.* The principal fossils are:—*Mantellia babbagensis* and *Zamites ensiformis.*

(viii.) *Eocene.* The Eocene Formation is represented by polyzoal coral and shell limestone, chalky limestone with flints, fossiliferous clays, calcareous sandstone, and shale.

(*a*) *Coastal Localities.* On the Murray River, from Bookmark downward to Murray Bridge, good sections of these rocks overlaid by Miocene strata are exposed; the Nullarbor plain, extending from Eucla to Denial Bay, and forming sea cliffs from 200 to 300 feet high between the head of the Great Australian Bight and the West Australian border; the coasts of Yorke's Peninsula, Ports Willunga and Noarlunga, Kangaroo Island, and other places to a less extent.

(*b*) *Localities Inland.* Near Ardrossan, McLaren Vale, Mount Jagged; at these places the beds are elevated to a height varying approximately from 200 to 700 feet above sea-level. On the Adelaide plains a bore at Croydon shewed a thickness of at least 2296 feet.

The deepest bore sunk for water on the Nullarbor plain penetrated a thickness of 500 feet of crystalline limestone and white chalky limestone with flints, succeeded by shale, gravel, etc., to 1387, where it bottomed on granite.

(*c*) *Fossils.* The characteristic fossils are:—*Magellania insolita, M. pectoralis, Magasella deformis, Salenia tertiaria, Scutellina patella, Cassidulis longianus, Lovenia forbesi, Fibularia gregata, Oxyrhina woodsii, Aturia australis, Voluta pagodoides, Fusis sculptilis, Turritella aldingæ, Natica aldingensis, Dentalium mantelli, Dimya dissimilis, Lima bassii, Pecten consobrinus, Pecten aldingensis, P. eyrei, P. flindersi, P. hochstetteri, Glycimeris cainozoica, Limopsis insolita, Chione cainozoica.*

(ix.) *Miocene.* This is represented by sand, clay, shale, loam, shell, limestone, sandstone grit, conglomerate, gravel, and boulder deposits. They fill the basins of ancient estuaries and old river beds, rising in the ranges and trending towards and into the sea, forming low cliffs along the coast and in its vicinity, and probably underlying newer formations at numerous places along the coast.

The oyster beds of the Murray Cliffs, Willunga, etc., are of this age.

(*a*) *Fossils.* The characteristic fossils are:—*Terebra crassa, Ancillaria orycta, Latirus approximans, Marginella hordeacea, Murex anceps, Cominella sub-*

filicea, Campanile triseriale, Semicassis subgranosa, Calyptræa crassa, Diastoma provisi, Heligmope dennanti, Natica subvarians, Ostrea sturtiana, Ostrea arenicola, Spondylus arenicola, Placunanomia ione, Pecten antiaustralis, P. palmipes, P. consobrinus, Lima semicostata, Lima jeffreysiana, Lithodomus brevis, Amussium lucens, Cucullæa corioensis, Mitylus submenkeanus, Cardita dennanti, Barbatia simulans, Meretrix sphericula, Trigonia acuticostata, Corbula ephamilla, Cardium mediosulcatum, Lucina nuciformis, Dosinia grayii, Tellina lata, T. basedowi, Myadora corrugata, Panopæa orbita, Plesiastræa st. vincenti, Loripes simulans, Macropneustes decipiens.

(x.) *Volcanic Rocks.* Basalt, dolerite, amygdaloid, lava, ash, etc., which have been derived from several points of eruption, cover limited areas in the south-eastern district in the vicinity of Mount Gambier and Millicent, and smaller areas in the hundred of Menzies, Kangaroo Island. Mount Gambier itself is composed of volcanic ash beds which at one time formed a portion of the walls of a crater. Mount Schanck is a perfect crater formed of beds of ash, scoria, etc. Other eruptive centres occur in the neighbourhood of Millicent. The basalt overlies beds of coralline limestone with flints of Tertiary age. The volcanic eruptions most probably took place at the same time as those in Victoria, where the basalt flows overlie Pliocene gold drifts. The Kangaroo Island basalt occurs as cappings in the hundred of Menzies, it rests on a formation similar to that of Yankalilla and Encounter Bay, the age of which has not yet been determined ; its thickness is about 100 feet, and its geological age is most probably the same as that of Mount Gambier.

(xi.) *Post-Tertiary (Pleistocene).* Sand, loam, concretionary limestone, clay, gravel, marl, gypsum, salt, shell limestone, sandstone, limestone, conglomerate, gravel, and boulder drift—these constitute the surface formations over a large extent of the plain country and the alluvium of the creek and gullies running through and from the ranges into these plains, and as cappings to all rocks of greater age. Alluvial gold occurs in these deposits in many parts of the State, and has been worked for to a greater or less extent on the various goldfields which have been discovered in the main range from Cape Jervis northward, and on the isolated ranges west of Lake Eyre.

Fossil remains of large extinct mammals (marsupial), birds, reptiles, amphibians, and fishes have been found. These include :—*Marsupials* : Diprotodon, Nototherium, Phascolomys, Sarcoptilus, Palorchestes, Macropus, Thylacoleo. *Aves* : Genyornis (Newtoni), Phalacrocorax. *Reptilia* : Crocodilia—Pallimnarchus Polleus, larger than any living species, a freshwater species allied to C. Johnstoni, but larger. Chelonia (tortoise)—Megalania Prisca, a gigantic land lizard. (Localities : Warburton River, Cooper's Creek in vicinity of Lake Eyre. *Pisces* : Ceratodus Silurard, and other fishes. The localities are as just mentioned.

The chief localities of the mammals are Adelaide, Yankalilla, Millicent, Baldina, Bundey, Mundowdna, Booleroo Springs, Lake Callabonna, Warburton River, and Cooper's Creek.

At Yankalilla and other places the remains of Diprotodon, etc., occur in soft spring deposits. At Lake Callabonna they are partially imbedded in the mud of the lake, in which they appear not to have been disturbed since their original deposition, and in other localities they occur in alluvium, either *in situ* or washed out by floods.

(xii.) *General.* Ice action is evidenced by glacial striæ on rocks of presumably Cambrian age, and on erratic boulders at Hallett's Cove and in the Inman River, and also by the occurrence of erratic boulders in the same district and on Yorke's Peninsula, Kangaroo Island, etc. There is no fossil evidence, but the deposit at Hallett's Cove underlies Miocene limestone, and may provisionally be regarded as of Mesozoic age. Erratic boulders are found strewn on the surface and imbedded in the Lower Cretaceous shales of the Central artesian basin.

6. **Geology of Western Australia.**[1]—The work of organising a systematic geological survey of Western Australia was commenced in 1896.

During the twelve years since then the mining industry has attained such magnitude that attention has been concentrated upon examinations in more or less detail at and around important mining centres. Any general knowledge of its geology as a whole can consequently be gathered only from information gained whilst travelling from centre to centre taken with the observations of previous geologists.

In Western Australia an enormous area is covered by crystalline rocks, and only a limited area discloses the sedimentary series. The most recent formations repose directly upon the oldest; thus in the southern portion of the State, where the prevailing formations are crystalline schists, they are fringed by deposits containing marine shells of existing types.

(*a*) *Physical Features*. The physical features of this State are in no way striking, the coast-line being generally very free from indentation and generally followed by low flat coastal plains at little elevation above the sea level, which again are followed by low ranges (the previous coast-line), whilst behind the latter are elevated plains, broken here and there by low ranges or isolated hills and areas of depression called "lakes." There are no mountains of an altitude known to exceed 3000 feet, whilst those rising from elevated plains do not as a rule present a striking appearance even locally. There are numerous watercourses but no flowing rivers, for these, owing to the gradual and uninterrupted fall of the land towards the coast, only run immediately after heavy rains, leaving only filled pools or waterholes behind.

The so-called lakes of the interior are, in reality, chains of wind-planed salt flats lying along main valleys, and they are connected one with another, thus forming the drainage channels of this flat country, but as a rule the rainfall is so light in the interior that the water accumulated upon them from the surrounding conntry simply evaporates, leaving its salt burden behind.

The general character of the land surface presents that of one which has for a long period been subjected to erosion, in the course of which it is highly probable that wave action in a shallow sea has played an important part, since this appears to be the only satisfactory solution of the problem as to how the detrital matter was removed. Portions of this area (particularly the elevated one) have undoubtedly been land surface for a very considerable period, as their laterite cappings conclusively prove.

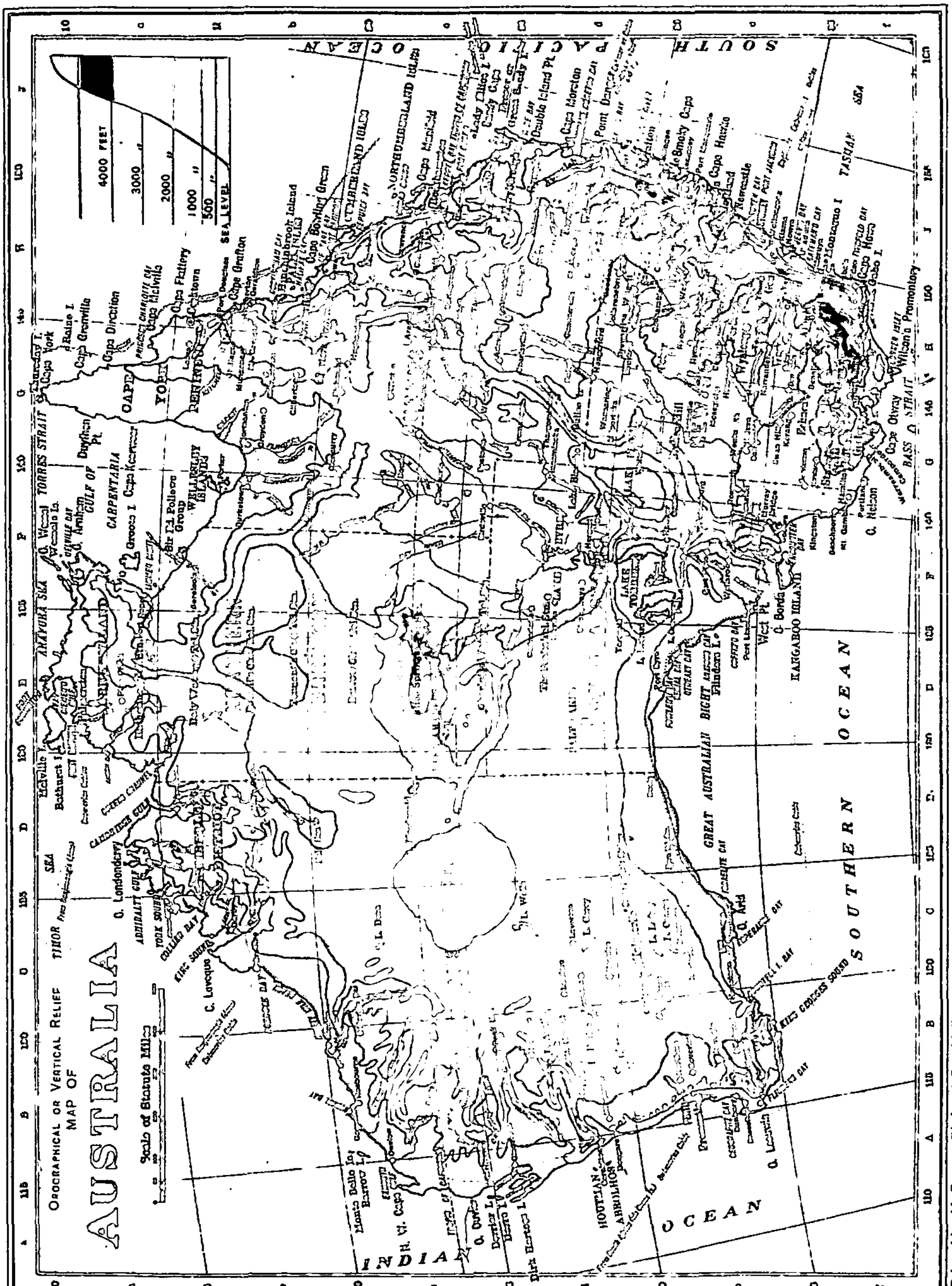
When we turn to the rocks this impression is further supported by the fact that the most modern stratified rocks as yet known here, after the Recent, are of Jurassic age; therefore we may safely conclude that the western portion of this continent has existed either as dry land or a group of islands in a shallow sea since the time at which an elevation took place in mid-Mesozoic times.

(i.) *Geological Formations*. The known geological formations of Western Australia are as follows:—

CRYSTALLINE ...	Igneous origin; Metamorphic origin (Pre-Cambrian?).
PALÆOZOIC ...	Metamorphic origin (Pre-Cambrian?); Cambrian, Devonian, Lower Carboniferous and Permo-Carboniferous.
MESOZOIC ...	Jurassic.
RECENT... ...	Superficial and marine deposits.
VOLCANIC ...	Sheets, flows and necks.

(ii.) *Crystalline Series*. The Crystalline rocks, which consist of granite, gneiss, schist and greenstone, cover an estimated area of 650,000 square miles, or a total of two-

1. In the absence of A. Gibb Maitland, Esquire, F.G.S., etc., Government Geologist of Western Australia, this article was contributed by Harry P. Woodward, Esquire, F.G.S., Assoc. M. Inst. C.E., Assistant Government Geologist of that State.



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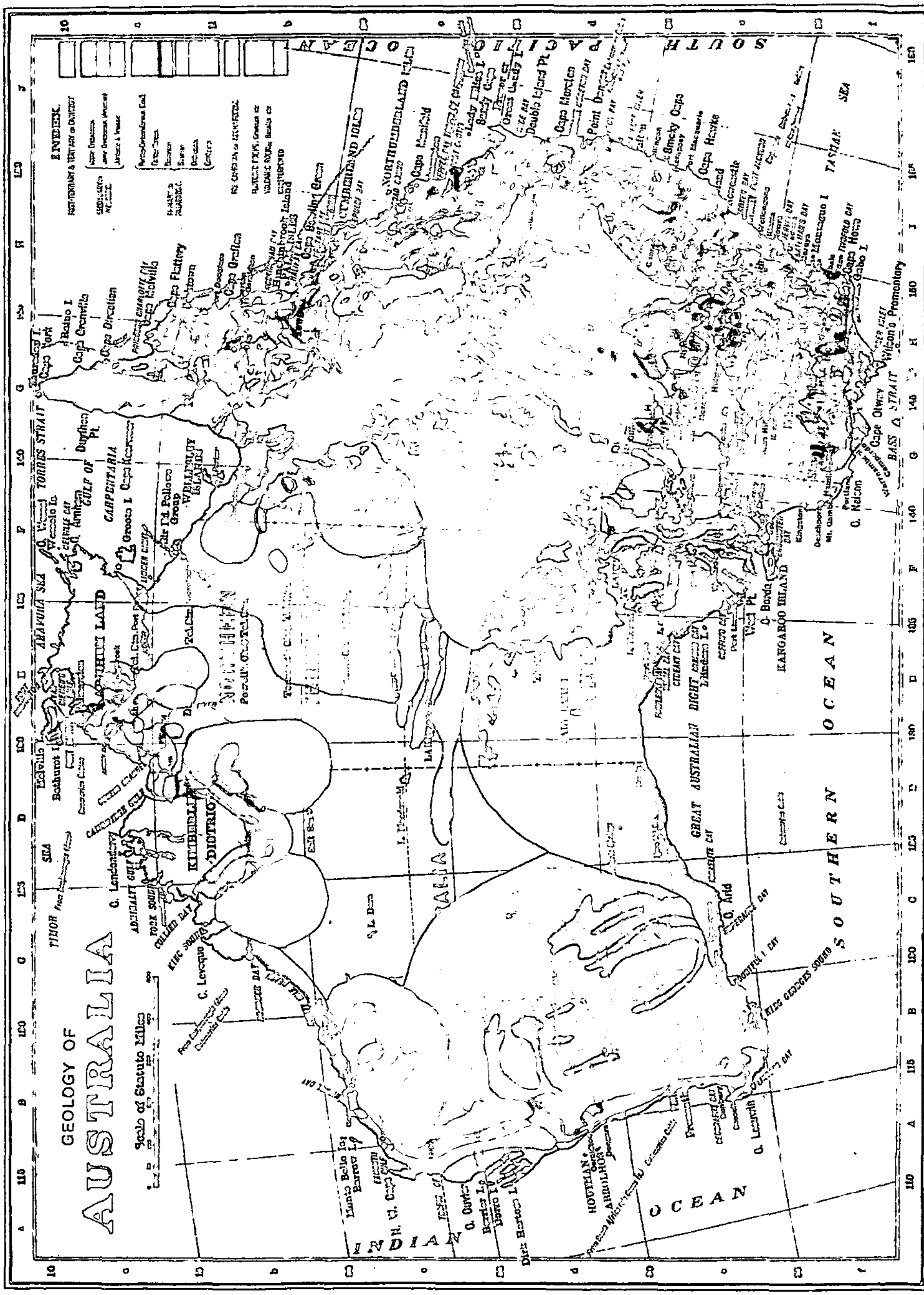

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thirds of the superficial extent of the State, and may be divided into three groups, the first of which comprises the granites, gneissic granites, and schists of the south-west division; the second, granites, gneissic granites and greenstones of the central and eastern portion of the State; and the third, granites, gneissic granites, schists and greenstones of sedimentary origin of Kimberley and the north-western districts.

(a) *First Group.* The first group is represented by a belt of gneissic granites and acidic schists, with intrusive granite and pegmatite veins, diorite dykes and quartz reefs, which occupy practically the whole of the south-western land division of this State; they occur in a belt that has a course a little west of north, extending from the south coast to the Murchison River, being about 200 miles in width at the south, extending from Point d'Entrecasteaux to Doubtful Island Bay, whilst to the northward as it impinges upon the west coast it narrows down to 125 miles.

Upon the western side of this belt, these rocks form a bold escarpment to the seaward, called the Darling Ranges. This face is evidently a fault line, since rocks belonging to a much more modern period are exposed in places at their base, where the talus covering them has been removed or pierced by wells.

This range forms the edge of an interior tableland, but does not attain any considerable elevation; the highest point, Mount William, is said to be 3000 feet above the sea level.

The question as to whether these rocks are of sedimentary or igneous origin has not yet been determined, but the uniformity of their foliation and apparent bedding, with the occurrence of graphite, would almost favour the former. They have so far proved of economic value only at two points, viz.: Northhampton at the north, where lead and copper lodes are found associated with porphyritic diorite dykes, and at Greenbushes at the south, where tin deposits occur in pegmatic and griesen dykes. The diorite dykes which have been intruded into these rocks are generally of an aphanitic character, whilst the quartz reefs are large and often contain marcasite in considerable quantities, but, although generally carrying both gold and silver in small quantities, discoveries of a payable nature have not yet been made.

Upon the south coast, and also upon the eastern side of the Darling Range, a series of magmatic intrusions of granite are met, which upon the coast form bold bare headlands and islands of rounded and polished dome-like shapes or fantastical ruined forms, and this character is maintained by the island outcrops, which generally follow the lake margins between the Great Southern Railway line and the goldfields.

(b) *Second Group.* To the second group, which occupies the whole area of the eastern goldfields, very considerable interest attaches owing to its economic importance, and therefore, it has been more closely studied than any other series in this State, but, unfortunately, as yet this close attention has only been paid to main centres of production, whilst with regard to the balance but little is known.

The rocks of this region vary from that first mentioned in the occurrence of what appear to be lenticular magmatic intrusions of basic rocks probably of diabase origin, which have been altered by the action of paramorphism and hydration into amphibolites, hornblende and chloritic schists and epidote rock, whilst portions less altered still retain a massive form consisting of epidiorite or diorite. These magmatic intrusions are contained in a gneissic country of doubtful origin, whilst intrusive granite, often magmatic, has at a more recent period broken through them and is frequently met with at the contact of the gneisses with the greenstones. Except where purely local disturbances have taken place, the planes of foliation lie in a north-westerly direction, or parallel to the long axis of the basic lenses, whilst the quartz reefs or lodes usually follow them, thus presenting a bedded appearance.

Basic dykes can be observed intersecting the gneissic rocks, whilst porphyritic and granite dykes are of common occurrence in the basic zone. It is probable, however, that the basic dykes also traverse the basic rocks, and the acidic the gneisses, but owing to their similarity in a weathered condition at the surface, it is difficult to determine their presence.

(c) *Third Group.* The third group includes rocks of undoubted sedimentary origin, in which the alteration is due in most cases to regional metamorphism owing to magmatic intrusions of igneous rock not necessarily always visible at the surface. These rocks are largely developed in the Kimberley and north-west districts, where the transition from undoubted sedimentary rocks of Palæozoic age can be traced into crystalline schists.

Although not crystalline, the slates, quartzites, and conglomerates of the same horizon, having undergone metamorphism, must necessarily be included in this group, and since both the crystalline and uncrystalline form the country rock of metalliferous lodes, they are of equal economic interest, and in consequence have received considerable attention.

In the Kimberley district the two main rivers, the Fitzroy and the Ord, take their rise at the same locality, the former flowing in a north-westerly direction and the latter north, forming roughly a horseshoe-shaped valley, which follows the anticlinal axis caused by a granite intrusion, the beds in contact with which have been altered into schist, whilst following and overlying them upon either side, an ascending series of Palæozoic age is exposed.

These rocks are intersected by numerous granite and diorite dykes, whilst a series of large auriferous quartz reefs and copper lodes occur both in the crystalline and uncrystalline portion of this series, following invariably the bedding planes of the rock.

In the north-west there is a greater complex of this series than in any other portion of the State, whilst they are of very considerable economic interest also since they contain a greater variety of metals and minerals than do the rocks of any other district. They have been very greatly disturbed and altered in places by intrusions of granite with pegmatite and diorite dykes, whilst at a more recent period the district has been the scene of very considerable volcanic activity, which has in all probability played an important part in the deposition of certain of the ores.

Under this section, the auriferous belt which includes both Norseman and Kalgoorlie has also been placed provisionally, but there exists very considerable doubt with regard to the soundness of this classification.

(iii.) *Palæozoic Series.* The Palæozoic Series, consisting of slates, shales, quartzites, sandstones, conglomerates, and limestones from which fossils have been determined to be of Cambrian, Devonian, Lower Carboniferous and Permo-Carboniferous age, are most largely developed in the Kimberley district, but in it as yet no rocks newer than the Lower Carboniferous have been identified, although it is quite possible the extensive shale beds may be of the Upper or even Permo-Carboniferous age.

In this series some small lead and copper deposits have been discovered in the Napier Range, but with this exception they have not so far proved to be of any economic value in this district.

(a) *Devonian.* In the north-west district the Government Geologist assigns the Nullagine series provisionally to the Devonian period, the beds of which consist of sandstones, grits, and conglomerates, with interbedded volcanic flows or sheets. Of this series interest attaches to the conglomerates, since they have proved to be auriferous in places, being very similar to the banket deposits of South Africa.

To the southward from the north-west coast this series of rocks is supposed to extend in a southerly direction for a considerable distance, probably as far as the Gascoyne River, forming a tableland through which the creeks have cut many cannon-like gorges, at the bottoms of which slates are exposed, whilst from the unconformable junction springs often flow.

(b) *Lower Carboniferous.* The Lower Carboniferous rocks are developed in the form of a long coastal belt, commencing a little north of the Ashburton River and extending southward across the Gascoyne and Wooramel Rivers, from which point they are lost until they outcrop again upon the Irwin River. It is, however, highly probable that they are continuous, their outcrops being hidden by superficial deposits.

This series north of the Wooramel consists of limestones, sandstones, shales, and conglomerates, with a general dip to the westward, and it is from them that the large supplies of artesian water have recently been obtained at several points.

(c) *Permo-Carboniferous.* The age of Permo-Carboniferous has been assigned by palæontologists to the rocks of three localities, viz., the Irwin River, Bullsbrook, a little north of Perth, and Collie, in the south-west. The rocks at the Irwin and the Collie consist of sandstones, grits, and pebble beds, with shales more or less micaceous and coal seams of a non-caking and poor quality, identical in composition with some of the Mesozoic coals of both Europe and America.

Some recent boring upon the Greenough River, a little to the northward of the Irwin River, has revealed beds of a similar coal. It is therefore possible that these are of greater extent than was supposed, and that they dip beneath the Jurassic beds which lie to the westward.

(iv.) *Jurassic.* The Jurassic Series, which consists of sandstones, light-coloured claystones, grits, and limestones, occurs in the Northampton district, extending south to the Greenough River. In all probability it forms a continuous belt southward from this point, following the coast to Gingin, which is about 40 miles north of Perth, in which locality fossils of a similar age are said to have been obtained, but, since in the intervening country the surface is practically all sand, no definite statement with regard to it can be made at present.

(v.) *Recent.* The Recent deposits consist of raised beaches at various points around the southern and western coast and coralline limestones and sandstones, which sometimes contain fossils or casts of shells of existing types, thus proving this section of the coast to be rising.

(vi.) *Volcanic.* Until quite recently the volcanic series was considered to be only represented by a basaltic sheet in East Kimberley and an outcrop of the same rock at Bunbury in the south-west. Later investigations, however, prove that it is of considerable extent and importance.

These rocks evidently belong to two distinct periods, the one consisting principally of andesitic rocks and the more recent of basaltic. They both occur in the form of dykes, necks, sheets, and flows, and are often vesicular, whilst the andesites are sometimes amygdaloidal.

Basalt occurs as extensive flows, forming the Great Antrim Plateau in the East Kimberley district, which extends into the Northern Territory of South Australia, and is also met with at many points in West Kimberley, but this latter has not as yet been geologically mapped.

At Bunbury it occurs in sheet form, assuming the columnar structure upon the beach, whilst southward from this point outcrops are met with in the Lower Blackwood River, and at Black Point upon the coast.

The andesites are gradually proving to be of much more frequent occurrence than was supposed, since the cleaved hornblende andesites were often mistaken for aphanitic amphibolites, into which they sometimes merge so imperceptibly that it is impossible to define a boundary. These rocks are largely developed in the north-west district, between the DeGrey River and the Ashburton River, whilst upon the Murchison goldfields they have been identified at Day Dawn, Cue, and Gabanintha, where they appear to have influenced the concentration of gold in the lodes.

(vii). *General.* A description of the geology of Western Australia would not be complete if the series of nondescript rocks called *laterites* were omitted, since they form one of the staple surface formations of this State. These rocks are supposed to originate from the gradual weathering *in situ* of schists containing iron, which, whilst in solution, is drawn to the surface by capillary attraction, and there deposited upon the evaporation of the water.

They are usually called ironstone gravel or conglomerates, and are found as cappings to most of the hills upon the goldfields, also covering all the ranges in the south-western district. The rock varies very greatly in both composition and character, the former being directly traceable to the parent rock from which it was derived, and the latter to the conditions under which it was formed. Nodular clay ironstone is by far its most common form, but it also often occurs in a massive state sometimes of considerable richness in iron, whilst at others it passes into a ferruginous sandstone.

No classification of the mineral veins has yet been determined upon, but typical examples exist of fault, dyke, shearing, discission, and shrinkage plane fissures, all of which possess one feature in common, no matter what class of ore is contained, which is that the matrix is quartz.

That the geological knowledge of Western Australia is at present very limited, is a natural consequence of the demand that the official staff shall give first attention to the study of economic problems. A considerable period must elapse before anything approaching a systematic survey can be undertaken.

7. **Geology of Tasmania.**[1]—Tasmania is a geological outlier of Eastern Australia. Its Pre-Cambrian and early Palæozoic history can be delineated only imperfectly. In Mesozoic times some connection existed with the Australian part of Gondwana land. In the early Tertiary it was separated from the adjacent island continent; subsequently the land connection was restored, to be again broken, since when it has remained an island. Dr. A. W. Howitt and Mr. C. Hedley have pointed out that the last land connection was between Wilson's Promontory in Victoria and Cape Portland in Tasmania, *via* Flinders Island and the Kent group, and that an elevation of from 200 to 300 feet would lay dry a tract of country between Victoria and Tasmania.

The rugged nature and the remoteness of the mountain fastnesses of the island have been great impediments to geological research. In spite, however, of the physical difficulties, it has been possible to fix the stratigraphy of a large portion of the State, though the lower Palæozoic strata need further study before they can be satisfactorily determined. As far as examination has proceeded the following systems can be recognised:—

i. PRE-CAMBRIAN.	iv. SILURIAN.	vii. TRIAS AND TRIAS-JURA.
ii. CAMBRIAN.	v. DEVONIAN.	viii. TERTIARY.
iii. ORDOVICIAN.	vi. PERMO-CARBONIFEROUS.	ix. QUATERNARY.

(i.) *Pre-Cambrian.* The diagnosis of the Pre-Cambrian must be accepted as provisional. It is probable that they belong to the Algonkian division of the group. Among them may be mentioned the quartzites and mica schists of the Port Davey districts. These are strongly developed in the south-west of the island as biotite and muscovite schists, greatly contorted, alternating with white saccharoidal quartzites, all striking north-west and dipping south-west. High headlands of quartzites, which have resisted denudation, jut out on the south coast, with bare, snow-white crests visible for many miles. Ores of copper, antimony, and lead occur in these schists. The contorted

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quartz schists and white quartzite of Rocky Cape, on the north-west coast, are also considered as Pre-Cambrian. These are traversed by granitoid dykes carrying copper ore. The quartzitic and micaceous schists west of the King William and Denison Ranges belong to the Pre-Cambrians. Garnetiferous amphibolite in the Collingwood River valley, the amphibolite of the Rocky River, enclosing lenses of magnetite with pyrrhotite and copper pyrites, and the zoisite-amphibolite of the Forth River, are also ascribed to the Pre-Cambrian group.

(ii.) *Cambrian.* This system is represented by friable, yellow sandstones, containing casts of Dikelocephalus, Orthis, Bellerophon, etc. These occur at two widely-separated localities on nearly the same meridian, one being on Caroline Creek, between Railton and Latrobe, the other on the Humboldt Divide and in the Florentine Valley. Mr. R. Etheridge reports that the fossils appear to be of Upper Cambrian age. The crystalline sandstones, quartzites, and conglomerate of which the Thumbs and Denison Ranges are composed are believed to be Cambrians.

(iii.) *Ordovician.* The slates and sandstones of the goldfields of Lefroy, Mount Victoria, Mathinna, Mangana, etc., in the northern and eastern parts of the island, are referred to this system, though few fossils of any stratigraphical value have been found. Their bearing is either east or west of north, and anticlinal axes are long and continuous. The gold quartz reefs which traverse them began to form apparently at the close of the Upper Silurian. Large and important mines have been opened on these reefs, and every geological consideration that can be adduced points to the permanency of the goldfields.

The conglomerates and sandstones at Beaconsfield, together with the blue limestones which prevail in that district at Blyth's Creek and Winkleigh, as well as the Chudleigh and Railton limestones, may be provisionally regarded as of Ordovician age. The Blyth's Creek limestone has yielded imperfect casts of corals, and the Railton quarries contain remains of Actinoceras and other cephalopods.

A series of clay slates occurs between Zeehan and Mount Read, known as the Dundas slates, and believed to be of this age. Ill-preserved traces of graptolites have been noticed in them. These slates extend to Mount Read, Mount Black, and the Red Hills, and along their junction with intrusive quartz porphyry rocks (felsite, keratophyre, granophyre, porphyroid, etc.) large lenses of complex gold and silver bearing sulphidic ores of zinc, lead, and copper have been formed.

Another group of rocks at the base of the Ordovician is the Gordon River series of limestones, sandstones and slates. The limestone in this group is fossiliferous. The organic remains include *Favosites*, *Orthoceratits*, *Raphistoma*, *Orthis*, *Rhynchonella*, *Euomphalus*, *Murchisonia*, etc. The limestone reappears to the north-east of Mount Farrell in the bed of the Mackintosh River, a short distance above its junction with the Sophia River. East of the Valley of Rasselas these rocks occur again in the Florentine Valley and at the Junee.

(iv.) *Silurian.* The Silurians are strongly developed at Zeehan on the West Coast, at Middlesex, and Mount Claude, Heazlewood, and the Eldon Valley, Queen River, etc.

At Zeehan, conglomerates and tubicolar sandstone underlie the limestones, slates, and sandstones, which are intersected by the numerous galena-bearing lodes which have the ore for which this field is so well-known.

The fossils found in limestone and quartzite belong to the genera Hausmannia, Asaphus, Illænus, Cromus, Rhynchonella, Strophodonta, Lophospira, Murchisonia, Eunema, Tentaculites, and the beds are considered by Mr. R. Etheridge to be homotaxially equivalent to the lower portion of the Upper Silurian.

Similar tubicolar sandstone occurs near Bell Mount, Middlesex, and on the Five Mile Rise, and casts of Hausmannia (or Phacops), Rhynchonella, Orthis, and coral have been found.

Clay slates in the Eldon Valley containing fossil casts of Calymene, Orthis, Cardiola, are considered to belong to the Upper Silurian.

At the Heazlewood limestone and sandstone have yielded remains of Hausmannia, Cromus, Cornulites, Rhynchonella, Tentaculites, and Favosites.

Sandstones and limestones in the Queen River district have been identified as Silurian (Middle or Upper Silurian). These are west of Queenstown. Brachiopods, and trilobites have been found also on the east side of the Lyell Razorback, indicating a similar age for rocks on the Lyell and Lyell Blocks mining properties there. The Queen River sandstones are charged with casts of Spirifera and Orthis.

Trilobite-bearing Silurian rocks also occur north of the Pieman River near the Wilson River.

In the Zeehan field the Silurian slates are largely accompanied by contemporaneous and intrusive sheets and dykes of vesicular melaphyre. The igneous rock corresponds very closely with the German spilite, an amygdaloidal diabase, sometimes called lime diabase.

Massive conglomerates crown most of the West Coast Mountains, the Dial Range on the North-west Coast, Mounts Roland, Claude, etc. These have generally been ascribed to the Devonian, but more recent data point to the commencement of the Silurian or even a still greater age as more probable.

The quartz-porphyries or felsites which form the backbone of the West Coast Range are the geographical axes of Mounts Darwin, Jukes, Huxley, Tyndal, Read, Murchison, and Farrell. They carry copper ore associated with lenses of hematite and magnetite, chloritic and felspathic copper-bearing schists, some of them, probably schistose porphyries, flank them and are enclosed in them. The felspathic schists of Mount Lyell belong to this group. Sufficient is not known of this geological formation to enable its age to be stated definitely.

Associated with the rocks of the Silurian system in the northern and western parts of the island is an extensive development of serpentine, the altered form of gabbro and its appendages, peridotite and pyroxenite. This rock is found at the Heazlewood, at Trial Harbour, in the Dundas district, in the Forth Valley, and near Beaconsfield. The difference of age between it and the Devonian granite is slight. Chronologically some of the granite is later.

(v.) *Devonian.* Granite occurs in a meridional line down the East Coast, extending from Flinders Island to Maria Island. It forms Mt. Cameron, Mt. Stronach, the Blue Tier, Freycinet's Peninsula, and is exposed at Ben Lomond and at the base of Mt. Arthur. Exposures are also seen at the Hampshire Hills, Granite Tor, Middlesex, the Magnet and Meredith Ranges, Heazlewood, etc. The quartz porphyry dykes at Mt. Bischoff, the tourmaline lodes at Mt. Black, and in the Dundas district, the stannite lodes and quartz-porphyry dykes at Zeehan, all denote a granitic reservoir below a large portion of the mineral fields on the West Coast. No granite intrusion into Permo-Carboniferous strata has been observed. The normal granite is a dark mica one, but muscovite and lithia micas appear in the tin-bearing varieties. Tin-bearing lodes occur on Ben Lomond and Mt. Heemskirk, while on the Blue Tier floors or stocks of altered granite form huge tin ore bodies of low grade. Porphyry dykes at Mt. Bischoff have shed the vast accumulation of tin ores which has been mined by the Mt. Bischoff Co. for the last thirty-four years with wonderful success.

(vi.) *Permo-Carboniferous.* The base of the system is formed by glacial conglomerates, grits, micaceous sandstones and flagstones, well seen on Bruni and Maria Islands and elsewhere in Southern Tasmania. Fossiliferous mudstones and limestones form a lower division of the system, while the upper division comprises the Tasmanite shale and coal measures of the Mersey basin, with upper marine mudstones and shales in the Mersey basin and at Hobart, and the coal measure series of Mt. Cygnet and Southport. The characteristic fossil plants of the coal measures of this system are Glossopteris, Gangamopteris, Noggerathiopsis. The seams average from 1½ to 2 feet in thickness, and the analyses show from 36 to 42 per cent. fixed carbon, 41 to 48 per cent. gas, 2 to 9 per cent. ash, and 8 to 12 per cent. moisture. They are known as the lower coal measures of Tasmania.

South of Wynyard and at Barn Bluff, cannel coal or kerosene shale is met with. The Wynyard or Preolenna seam of this coal is in sandstone overlying fossiliferous mudstones, and assays up to 76 per cent. volatile matter. The Barn Bluff cannel coal has only been observed in loose blocks, supposed to have been distributed by glacier action.

At the close of the system, or during Mesozoic times, a local intrusion of alkaline rocks, alkali and nepheline syenites, etc., occurred, traversing the Permo-Carboniferous strata south of Hobart, from Oyster Cove and Woodbridge on the Channel to the Huon River in a N.E.-S.W. line. Auriferous quartz and pyrites have been developed near the line of the contact of these igneous rocks with the Permo-Carboniferous sandstones and mudstones, and a good deal of free gold has been shed into the flats.

(vii.) *Mesozoic.* The fresh-water beds, which succeed the Upper Palæozoic, belong to the Mesozoic division, but cannot as yet be subdivided with certainty. The nearest approach to a subdivision would be as follows: but the reference to European equivalents is nothing more than an attempt at correlation homotaxially:—

(a) Trias (?) 1. Variegated sandstones with remains of heterocercal fishes and amphibians.
2. Sandstones and shales with coal at Ida Bay.
(b) Jura (or Rhætic). 3. Upper coal measure sandstones.
(c) Cretaceous (?) 4. Diabase in intrusive masses, sills and dykes.

The variegated sandstones occur at Knocklofty, the Domain, Ross, etc. Remains of Acrolepis have been found at Knocklofty and Tinderbox Bay. Bones of an amphibian (labyrinthodontine?) have been obtained from the Government House quarry in the Domain.

The upper sandstones are readily recognised by their soft felspathic nature: they are generally greenish-grey to yellowish-brown, sometimes white. They are widely distributed throughout Eastern and South-eastern Tasmania, and occur also in the extreme south. They are largely interrupted by intrusions of diabase. They flank the central, eastern and western tiers, and fringe isolated mountains, *e.g.*, Mt. Nicholas, Mt. Victoria, Ben Lomond, Ben Nevis, Mt. Dundas, Cradle Mountain, etc. From Fingal and Mt. Nicholas they extend on the outskirts of the diabase ranges southward to Seymour, Bicheno, Llandaff, Spring Bay, and all over South-eastern and a large part of Southern Tasmania.

These measures enclose the coal seams, averaging from 4 to 12 feet, which are worked at the Mount Nicholas, Cornwall, York Plains, and Sandfly collieries. The analyses of this coal range from 53 to 60 per cent. fixed carbon, 23 to 31 per cent. volatile matter, 9 to 16 per cent. ash, 2 to 4 per cent. moisture, and the coal is not a coking one. A sub-anthracitic coal is raised at York Plains, and at the Sandfly mine a seam of anthracite occurs containing 80 per cent. fixed carbon and 8 per cent. volatile matter.

The fossil flora from these measures must be regarded as characteristic for the Mesozoic. The list includes Thinnfeldia, Pecopteris, Tæniopteris, Sphenopteris, Alethopteris, etc.

The diabasic intrusions cut up the coal measure areas into different basins and cover large portions of the Central, Eastern and Southern districts.

(viii.) *Tertiary.* A great stratigraphic break exists between the Mesozoic and the succeeding strata. This Tertiary system cannot be subdivided as in Europe. The two divisions, Palæogene and Neogene, are adopted in Tasmania. According to this arrangement, the subdivisions are as follows:—

(a) Neogene (= approximately to Pliocene).
Under this head would fall various river terraces and estuarine deposits.

(b) Palæogene (= Eocene to Miocene).
3. Basalt lavas.
2. Fluviatile and lacustrine clays and sands, tin ore drifts, and deep leads.
1. Fossiliferous marine beds at Wynyard (= Eocene).

The marine fossiliferous beds at Wynyard are covered with the basalt which, generally throughout the island, appears to separate the Lower from the Upper Tertiaries. The extensive lacustrine deposits within the watershed of the Tamar cover an area of 600 square miles, and embrace widely-spread pre-basaltic or Palæogene clays and sands, which form a series 900 to 1000 feet thick. Such sediments with fossil leaves of European genera occur at Launceston, Dilston, Windermere, Beaconsfield, Waratah, Strahan, St. Helens, Burnie, and on the Derwent. In the north-east and east, the sub-basaltic gravels are worked on a large scale for tin ore, and yield most of the alluvial tin of the State.

At the close of the Palæogene a great outpouring of basaltic lava took place, and this rock is very general throughout the Island, though rarer on the West Coast.

The rock is usually olivine basalt, but nepheline basalt occurs on the Shannon Tier, and at Sandy Bay, Hobart.

The Neogene valley terraces can only be distinguished from the earlier Tertiaries by position and lithological characters. Some of the gravel drifts of the Derwent, of the Longford plains, and in the neighbourhood of Launceston, belong to this subdivision. The close of the Tertiary, or the beginning of the Quaternary, witnessed a glacier epoch in the west and centre of the island. The highlands round Barn Bluff, Mounts Tyndal, Lyell, Sedgwick, Jukes, Darwin, etc., and the western edge of the great central plateau abound with tarns, ice-scratched stones, and moraines. No proof of glacier conditions in this period in the eastern part of the island has been adduced yet.

Tin and gold ores are the most important products of the deposits of the Tertiary system. They are won from the alluvial gravels and leads of the period. The sands in the Savage River and other tributaries of the Pieman and Huskisson have been worked for osmiridium. Zircon sand, near Table Cape, has also been exploited. Tertiary clays are used largely for brick-making and pottery, the gravels for road-making. Lignites exist, but are not yet industrially important. Though there has been great volcanic activity, there are no signs of Tertiary metalliferous veins.

(ix.) *Quaternary.* These deposits may be classed as follows :—

(a) Recent.

3. River alluvium and sand dunes.
2. Raised beaches and helicidæ sandstone.

(b) Pleistocene.

1. River drifts.

The later terrace drifts in the valleys of existing rivers are referred to the Pleistocene. Sand dunes, consolidated to shelly sandstones, occur on Cape Barren, Badger, Kangaroo and other islands in Bass Straits, containing shells of Helix, Succinea, etc. These sandstones sometimes overlie a raised beach. The raised beaches on the North and South Coasts indicate elevation within the Recent period.

(x.) *Ore Deposition.* The period during which the deposition of metalliferous ores was most active was the interval between the Upper Silurian and the Permo-Carboniferous. Ore deposition has been associated principally with the consolidation of the gabbroid and granitic masses. Nickel sulphide and osmiridium owe their origin to the serpentine at the Heazlewood, Trial Harbour, and Dundas. On the other hand the granite magma is responsible for the lodes of silver lead all over the island, whether these pierce quartz porphyry as at the Devon and Mount Tyndal, slate, sandstone and limestone as at Zeehan, or ultra basic dyke rock as at the Magnet. The pyritic lead, zinc, or copper ores of the West Coast Range (Mount Lyell, Mount Read, Mount Black, etc.) are also most probably due to the action of the acid magma. Tin and wolfram ores are naturally referred to the same source, and the gold quartz reefs of the Ordovician strata must be regarded as the result of the expiring effort of the cooling magma to get rid of its surplus available silica. A few veins of barren quartz occur in the Permo-Carboniferous strata, but beyond the exceptional case of the alkali porphyries at Port Cygnet, the chapter of metal-bearing lode action closed, as it began, with the Devonian period. Within that period, therefore, were accumulated the great stores of mineral which the mining industry of Tasmania is now drawing upon. The mines of gold, silver, lead, copper, and tin, rank high among the famous mines of the world. Her mineral wealth may, in fact, be considered remarkable, when despite the small area of the island (26,000 square miles) the value of the mineral produced for the year ending 31st December, 1907, amounted to £2,277,159. The industry is thriving, is on a sound and established basis, and with the careful administration and care which it receives it may with confidence be expected to continue a highly important asset of the State for a quite indefinite period of time.

§ 6. The Fauna of Australia.[1]

1. **Zoological Isolation of Australia.**—The most striking character of the Australian Fauna is its distinctness from that of the rest of the world. This character is evinced as much by the peculiarity of the animals found in Australia as by the absence of others which are widely spread over the remainder of the earth's surface. In consequence of this some zoogeographers have divided the earth into two regions, Australian and non-Australian.

The land-fauna of the globe is, as a rule, limited in its migrations by the sea. Other barriers to the spread of species may be now and again overstepped, but the sea imposes restrictions that remain absolute under the existing conditions. Geology, however, teaches us that the sea has once rolled where our highest mountains stand, and that the sites of former lands are now sunk beneath the waves. Here then we find a clue to the presence on all the larger land areas of terrestrial animals. The marine barrier that now separates them is but a passing feature; they were once united and they may yet be so again, and while the union existed there was a free interchange of inhabitants.

The older a group of animals is the farther could it spread, for it has been able to make use of many land connections that have now vanished. Thus, the *Felidæ* and *Suidæ* (cats and pigs) are old enough to have found their way over almost the whole habitable globe, excepting Australia and a few islands to the north. Alone of the great islands of the world, our island-continent has remained separated from the other great land masses since the first appearance of the *Felidæ* and *Suidæ*, and so none have reached it.

Facts of a similar nature, almost numberless, may be brought forward in confirmation of this conclusion. Animals and plants alike bear evidence to its truth, and thus we see how the deficiencies of the Australian fauna are accounted for. The barrier that prevented the incursion of the adaptable and enterprising cats and pigs was equally efficient in the case of a host of other forms, from elephants to earthworms.

2. **Effect of Isolation.**—Before this isolation of Australia, however, some animals had reached our shores, and among them were the marsupials. Once here, they were protected by isolation from competition with the more specialised forms that came into existence elsewhere. They varied among themselves, and gave rise to the diversified forms that now inhabit the country.

There are other groups besides the marsupials whose history runs on similar lines. Of some of them we know this history, but not of all, and the deciphering of the tale of the early origin of the fauna of Australia is one of the many interesting pieces of work that lie before the naturalist.

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3. **The Non-marine Fauna.**—The chief interest in Australian fauna centres round the dwellers on land and in fresh water. It is they who shew the peculiarities just noticed, whereas the marine forms are more widely spread, since barriers to their migration are more easily burst through. The fauna of the Pacific Ocean differs in many points from that of the Atlantic, but is linked more or less closely with that of the Indian Ocean, so that it is usual to speak of an Indo-Pacific region. The widespread character of the marine fauna as opposed to that of the land will render it advisable, owing to limitations of space, to concentrate our attention on the latter, though we must, in consequence, pass by much that is of interest.

(i.) *Mammalia.* The great group of mammals has been divided into two sections, the *Prototheria* or egg-laying mammals, and the *Theria*, which includes all the rest. The *Theria* are again subdivided into numerous sections, one of which is that of the marsupials. For a long while the marsupials were separated from the rest of the *Theria* on account of certain peculiarities connected with gestation. The young are born in a very undeveloped condition, and usually there is, during development, no organic connection between the fœtal and maternal tissues, or in other words, no placenta is formed. However, recent research has shewn that a placenta is present in the native cat (*Dasyurus*), and as it is universally present in all *Theria* other than marsupials the criterion fails. *Dasyurus* cannot be separated from the other marsupials, so all must belong to the one group, which is called *Theria*.

The egg-laying mammals are confined to Australia, Papua and Tasmania, and there is no absolutely conclusive evidence of their ever having lived elsewhere. As regards marsupials, they are found nowadays only in Australia and some adjacent islands, and in America as far north as the Southern United States. In former times, as we know from fossils, they ranged still further north and lived even in Europe.

(a) *The Higher Theria.* In the *Theria* above the marsupials we are poorly off. The Dingo (*Canis dingo*) reached Australia while the giant mammals were still living, and his bones occur as undoubted fossils, a fact proved some forty years ago, but still not accepted by many foreign naturalists. There are several kinds of true rats (*Mus*) and a widely spread water-rat *Hydromys chrysogaster*), as well as a few other kinds. Bats are common, for both they and rats have found their way all over the globe, excepting to a few remote islands, and this without the aid of man, and in fact before his appearance on the scene. The largest bats we have belong to the genus *Pteropus*, and are fruit-eaters, being a great scourge to orchards in the warmer parts. They are generally spoken of as flying foxes. Another large bat, a white one (*Megaderma gigas*), is found in caves far inland.

Seals, whales, and the dugong being marine forms, must be passed over.

(b) *Marsupials.* The group of Marsupials has, in Australia, reached its highest stage of development, and, as the other *Theria* are almost absent, its members have become differentiated in almost every direction to occupy their places. Thus we have the grass-eating kangaroos, the flesh-eating Tasmanian wolf and Tasmanian devil, and the "tiger cat," the insect-eating native cats and "weasels," the ant-eating marsupial mole and banded ant-eater, the root-eating wombats, the omnivorous bandicoots and leaf-eating koalas. One great group of land *Theria* has no counterpart. There is no marsupial bat.

Marsupials have been divided into two main groups which, roughly speaking, though not exactly, correspond to carnivorous and vegetarian. This usual, but somewhat unsatisfactory, classification is founded on the teeth. An examination of the lower jaw of a wombat, kangaroo, "possum," or a few other forms, will shew that there are two strong teeth in front, the incisors. Usually only two are present. This gives the name to the group, *Diprotodontia*, that is, "two teeth in front." Most of its members are vegetable feeders. The other group comprises forms with several lower incisors—the *Polyprotodontia*, "many front teeth." These are almost entirely flesh-eaters. A more modern classification, and apparently a better one, is based on the structure of the foot. In the kangaroo, what appears to be a single toe on the inner side of the hind foot bears two claws. In reality there are two toes present which are bound together by skin. This feature is known as "syndactyly," and gives its name to the group, *Syndactyla*. The other group comprises the remaining marsupials, and is known as *Diadactyla*.

(c) *Prototheria* or *Monotremes*. The egg-laying mammals, in their strange method of reproduction, and in certain points in their structure, shew a decided approach to the reptiles, and they are widely separated in many ways from the higher mammals. They include only the platypus (*Ornithorhynchus anatinus*) and the spiny-ant-eaters. The platypus is found only in Eastern Australia and Tasmania, and does not range up very far into Queensland. Its curious duck-like bill is so extraordinary that the first skins sent to Europe were viewed with suspicion. The memory of the mermaid, made up of fish and monkey skin, was too recent to be forgotten. Although the adult has no trace of teeth, strong bony teeth are present in the young, and are shed only when the animal is about half-grown. Their place is supplied by horny pads, which are quite efficient for the work they have to do. The platypus makes its nest at the end of a long burrow in a river bank, the entrance being below water-level. The eggs have no hard shell, but are soft like those of the reptile.

The spiny-ant-eaters are represented on the mainland and in Tasmania by the well-known *Tachyglossus aculeata* or *Echidna aculeata*, and in Papua by an allied form with a somewhat longer beak. The beak is narrow and rounded, and the long tongue, covered with a viscid secretion, is a very effective instrument for the capture of the ants on which the animal lives. The spines with which the body is covered are colour-banded like those of the true porcupines of the northern hemisphere, but are much shorter. When attacked the animal rolls itself into a ball. It is of great strength, burrows vertically downwards with extreme rapidity, and is an expert rock climber. The two eggs are hatched in a pouch which superficially resembles that of the marsupials. Though possessed of a pouch and "marsupial" bones, the egg-laying mammals are not, in the ordinary sense of the term, allied to the marsupials.

(ii.) *Diadactylous Marsupials*. Confining our attention to the Australian marsupials, we find the *Diadactyla*, which have the second and third toes separate, are represented only by a single family, the *Dasyuridæ*, or native cat family. This family is apparently less changed from the original marsupial stock than is any other Australian one. The "native cats" (*Dasyurus*), the several kinds of which vary in size from that of a pug-dog to that of a ferret, are nearly all spotted with white, the body colour being brown or black. They are found all over Australia, from Tasmania to New Guinea. A number of small species exist, ranging in size from a half-grown kitten to that of a mouse, and belonging to two other genera (*Phascologale* and *Sminthopsis*). Popularly they are called weasels and mice. Some of them are terrestrial, others arboreal. There is a peculiar jerboa-like little species (*Antechinomys laniger*), which is found throughout the drier interior. The banded ant-eater (*Myrmecobius*), about the size of a rat, has a similar range, but seems commoner on the western side of the continent. The Tasmanian Devil (*Diabolus ursinus*, or *Sarcophilus ursinus*), now confined to Tasmania, is a clumsy, hideous, black and white blotched animal, about as large as a pug-dog. Its ferocity and strength justified its name.

The last member of this family is the Tasmanian wolf or tiger (*Thylacynus cynocephalus*). It is about the size of a retriever, but with a much longer body. The cross-banded back gives it the name of tiger, which is the one generally used. It is a fierce, predatory animal, but is rapidly becoming exterminated. Like the Tasmanian Devil, it formerly lived on the mainland, and its fossil remains have been found as far north as the Darling Downs. All authorities are not agreed that the "tiger" should be included in the same family as the animals previously mentioned. Some place it in a family by itself; others group with it certain South American extinct animals known as Sparassodonts; others again hold that the latter forms are not marsupials at all, but a sort of connecting link between them and an ancient group, the *Creodonta*, which gave rise to the modern *Carnivora*, and to the *Marsupialia* as well.

(iii.) *Syndactylous Marsupials*. Taking now the remaining Australian marsupials, we find that they all have the second and third toes bound together; they are *Syndactyla*. Two families are polyprotodont, namely the *Peramelidæ* and the *Notoryctidæ;* the others are diprotodont.

The *Peramelidæ*, or bandicoot family, comprises several animals mostly about the size of a large rat. They are ground-dwellers, and range over all Australia. The marsupial-mole *(Notoryctes)* forms a family by itself. It is about the size of a newly-born kitten, golden yellow in colour, quite blind, its eyes being very rudimentary and covered by the muscles of the face. On hard ground it is a clumsy, sprawling walker, but in sandy soil a remarkably rapid burrower, its great, shovel-shaped claws enabling it to sink out of sight almost at once. It has a remarkably restricted area of distribution, being confined, as far as is known, to the basin of the Finke River in Central Australia, though there is the probability that it is to be found in Western Australia.

The remaining families are diprotodont. The *Phalangeridæ* include the Australian "possums" *(Trichosurus)*, which have wrongly appropriated the name of the true or American opossums. The value of the skins of these animals for furriers' purposes leads to their slaughter by millions annually, and they have now disappeared where they were once common. Some allied forms *(Petaurus, Dromicia* and *Acrobates)* have a fold of skin stretching from the hind to the fore-limb, which enables them to glide from a greater to a lesser height. Collectively, they are spoken of as flying-squirrels, though they cannot fly and are not squirrels. The Koala, Kola, or native bear or monkey-bear (*Phascolarctos*), a lethargic leaf-eater, belongs to this family.

The *Phascolomyidæ*, or wombat family, contains only one living genus (*Phascolomys*), which is confined to the south-east and Tasmania. The wombats are inoffensive burrowers, but unfortunately are apt to damage crops where they are common, and their great strength and burrowing powers make fences but poor protection against their inroads.

The kangaroo family (*Macropodidæ*) is a large one, and its members vary in size from the giant, standing higher than a man, to the Musk kangaroo of the Herbert River, which is about ten inches long. The larger forms were dwellers on the open plains, where, with scarcely any foes, they grazed in countless thousands. Now, like the bison of America, they are passing away. The smaller kangaroos which belong to various genera, and are spoken of as wallabies, frequent the scrubs and rocky fastnesses of the mountains. The tree kangaroos of Queensland and New Guinea (*Dendrolagus*) browse on the leaves of lofty eucalypts, which they climb to their topmost branchlets.

Among extinct marsupials we have *Diprotodon*, as large as a rhinoceros, but as inoffensive apparently as a wombat, which it seems to have resembled much in appearance. *Thylacoleo*, a huge carnivorous monster, greater than a polar bear, was allied to the phalangers. There were also giant kangaroos, standing a dozen feet high, and wombats as large as an ox. On the other hand there was a dwarf wombat, about a quarter of the size of our recent species. The oldest known Australian marsupial, *Wynyardia*, is of Oligocene or perhaps Eocene age.

(iv.) *Aves*. Birds shew the same characteristics that the mammals do. Deficiencies, as well as the presence of peculiarly Australian forms, serve to distinguish Australia from the rest of the world. Among the groups which are eminently characteristic are the birds of paradise, which have their home in New Guinea and just pass into Northern Queensland. Of pigeons, we have more species than the rest of the world, and we have the largest and the smallest kinds. The cassowary and the emu, forming a single family, are unknown beyond our regions. The cassowary (*Casuarius*) is found in the forests of New Guinea and North Queensland, and the emu (*Dromæus*) ranges over all Australia, and, till it was exterminated, was common on Kangaroo Island, the islands of Bass Straits, and Tasmania. The brush-tongued lories (*Trichoglossidæ*) follow the flowering of the honey-yielding eucalypts throughout Australia. The honey-eaters (*Meliphagidæ*) are among our most characteristic birds, though they pass far beyond Australia itself, and out across the Pacific, even to the Sandwich Islands. The larger ones are sought for food, while some of the smaller kinds, which have developed a taste for orchard fruits, are at times a scourge. The peculiar mound-nests of the *Megapodidæ*, where the eggs are hatched after the manner of those of reptiles, are very characteristic of Australia, though not confined to it. Among other strange forms are the bower birds (*Ptilonorhynchidæ*), whose habit of building playing-runs and decorating them with bones, shells, flowers, and so on, has often been described. The lyre birds (*Menuridæ*) are remarkable for their peculiar tail feathers. They are inhabitants of dense fern-gullies in Eastern Australia. Their allies, the scrub birds (*Atrichidæ*) are confined to the dense forests of the warm east coast, and of West Australia. The most striking absentees, whose abundance in Eastern Asia makes their absence here so remarkable, are the pheasants and vultures, while there are other abundant East Asiatic forms which are poorly represented amongst us.

(v.) *Reptilia.* Among reptiles we have the estuary crocodile (*Crocodilus porosus*), occurring commonly in the northern rivers, and ranging from India to the Solomons, and even it is said, as a stray, to Fiji. A small, harmless species (*Crocodilus johnstoni*) is found in the fresh waters of the north. Of freshwater tortoises there are three genera represented (*Chelodina*, *Emydura* and *Elseya*). None occur in Tasmania. These tortoises tuck their heads into their carapaces by an S-shaped fold in a horizontal plane, and belong to a group whose other representatives are found in South America.

Among lizards the most peculiar are the so-called legless lizards (*Pygopodidæ*), which are confined to Australia. In them the front limbs are completely absent, and the hind limbs are represented only by a pair of short flaps, which fit into grooves at the side of the body, and so easily escape detection. The family contains seven genera, *Pygopus*, *Delma*, and *Lialis* being the most widely spread. The skinks (*Scincidæ*) are the most numerous Australian family, and the *Varanidæ*, commonly called "goannas," contain the largest of our lizards. Altogether we have about 390 species of lizards.

There are slightly more than 100 species of Australian snakes, about three-quarters of them being venomous. The number of non-poisonous forms decreases as the latitude rises, so that in Tasmania none are found, all the snakes being venomous. The harmless kinds include the blind snakes (*Typhlopidæ*), which have very smooth, glassy skins, and are burrowing forms, living principally on termites, and therefore deserving of careful protection. The pythons and rock snakes are the largest of our Ophidia, but are also harmless. *Python spilotes*, the diamond and carpet snake of the mainland, is beautifully mottled. It grows to a length of about 10 feet, and is found throughout Australia. The long, slender, green tree-snake (*Dendrophis punctulatus*) inhabits almost the whole of Australia. It is quite harmless and feeds on tree frogs, young birds, and lizards. Though so many of our snakes are poisonous, only five common forms are really deadly. These are the brown snake (*Diemenia textilis*, or *Demansia textilis*), the black snake (*Pseudechys porphyriacus*), the copperhead—unfortunately called diamond snake in Tasmania—(*Denisonia superba*), the tiger snake (*Notechis scutatus*), known in Tasmania as the carpet snake, and lastly the death adder (*Acanthophis antarctica*). The first four all occur in Tasmania, and are the only snakes found there. The tiger snake is the boldest of all, and commonly shews fight. The death adder, a short, thick-bodied snake, is very lethargic, and often allows itself to be trodden on, when it strikes with lightning-like rapidity and deadly effect. None of our snakes have long enough teeth to make their bite, when made through clothing—even a single thickness of tweed—a cause of dread.

(vi.) *Amphibia.* In amphibia the most striking fact is the absence of tailed forms (*Urodela*). The characteristic old world genus *Rana* just invades North Queensland.

We are especially rich in tree frogs (*Hylidæ*), some of which as *Hyla aurea*, the common southern green frog, have lost their tree-climbing habits and the adhesive suckers on fingers and toes. The *Cystignathidæ*, which include the common sand frog of the south-east, occur also in South America. The water-holding frog, with its body enormously distended by water, can live for a year or more in thoroughly dried mud. It is found in Central Australia.

(vii.) *Pisces*. Owing to our poor river development, Australia is not rich in fresh-water fish. The great river basin of the Murray has several species peculiar to itself, as the Murray cod (*Oligorus macquariensis*), the golden perch (*Plectroplites ambiguus*), the silver perch (*Therapon ellipticus*) and the catfish (*Copidoglanis tandanus*). Of these, the Murray cod, owing to stream capture and the consequent alteration of drainage areas, has invaded the head waters of a few other rivers, as the Richmond and Clarence Rivers in New South Wales. Another curious instance of distribution is that of the blackfish of the south-east (*Gadopsis marmoratus*). This is almost confined to rivers entering Bass Straits, it being found in Northern Tasmania and Southern Victoria. These streams are the now separated upper-waters of a river which drained the plain now occupied by Bass Strait, and entered the ocean to the north of King Island. River capture has carried blackfish into the upper waters of the Goulburn and the Loddon. Eels, which are common in all streams from Cape York to Beachport, are absent from the entire Murray basin and Central and Western Australia, and apparently from Northern Australia as well. The southern trouts (*Galaxias*) are found in the streams of south-eastern Australia and Tasmania. Elsewhere they are found in South Africa, New Zealand, Patagonia and Chile. As some of the species, but not all, breed in the sea, the distribution of the genus is not as remarkable as once was thought. The gudgeons or bullheads (*Gobiidæ*) have representatives in fresh water all over Australia. None of these grow to any size.

The most remarkable of all our fresh-water fish, however, is the Lung fish (*Neoceratodus forsteri*) of the Mary and Burnet Rivers of Queensland. It is one of the three surviving species of an ancient and once world-wide group of fish. As its name implies, it has a lung, a modified swim-bladder, in addition to the usual gills. When the water is foul it comes to the surface to breathe. It cannot, as its African relatives do, live in the mud of dried-up ponds.

(viii.) *Invertebrate Fauna*. In land and fresh-water shellfish we are not well off. The eastern coastal strip from Cape York well into New South Wales is closely related to Papua in its shellfish, as it is also in so many other ways. There are many genera of the Helices. Of the rest of Australia the western State seems the poorest in molluscs, though many of its inhabitants range right across to the eastern highlands.

Among insects, the butterflies of the warm damp Queensland coastal districts vie in beauty with those of any part of the world. As we retire from this region their number and size decrease. The wandering butterfly, a black and white species, at times appears in countless myriads and travels far out to sea. We are especially rich in beetles of the families *Buprestidæ*, *Curculionidæ*, and *Cerambycidæ*, the members of the first family containing some very handsome insects. White ants are plentiful, especially in the tropics. One species is remarkable for its narrow, wall-like nests, which have their long axes along the north and south line.

Among crustacea a species of *Apus* is found in the interior, and the allied *Lepidurus* in the southern coastal districts. The peculiar isopod, *Phreatoicus*, and some allied genera, are found in our mountain streams or burrowing in the damp southern gullies. *Koonunga*, a recently described Anaspid, is an annectant form between the stalk-and sessile-eyed groups. Among the higher crustacea belonging to the *Parastacidæ* are the genera *Astacopsis* (*Chærops*), which is spread all over the continent, and *Engaeus*, found only in Tasmania and Southern Victoria. The larger species of *Astacopsis* are used as food.

Among the flat-worms, *Linstowia* is peculiar, as it is confined to the monotremes and the marsupials of Australia and South America. The genus then must date back to Mesozoic times. *Temnocephala* infests the fresh-water crayfish, and is curious on account of its distribution, as it ranges up into America, and, strange to say, an allied form has recently been recorded from Southern Europe.

Australia is rich in earthworms, but the native species are being ousted by European forms. *Megascolides* is remarkable for the size of one of its species, the giant earth worm of Gippsland (*M. australis*), which reaches a length of over seven feet, and is as thick as a man's finger. The *Acanthodrilidæ* are distinctly a southern family, being especially plentiful in Australia, New Zealand and South America, and gradually becoming fewer in species as we pass north from these lands.

To attempt to deal with the fresh-water protozoa would make too great demands on space, and for the same reason the whole of the marine fauna must here be passed over in silence.

4. **Origin of the Fauna.**—The place of origin of our Fauna and its route of entry into Australia has been much discussed. As mentioned previously, it consists of several constituents. The marsupials, and probably some of the birds, the tortoises, the cystignathid frogs, some fresh-water fish (as the Galaxiidæ and some others), many insects and earthworms, have their nearest living allies in South America. These represent ancient groups, and probably date back to the times when a great antarctic continent existed, of which the southern lands are but isolated fragments.

Much of the remaining Fauna has a northern origin, as the dingo, rats, bats, most of our flying birds, lizards, fresh-water crayfish, and probably the bulk of our insects. The evidence of a Malayan incursion, both of plants and animals, is specially strong along the damp seaward slopes of the eastern coast range of Australia.

The native Australian Fauna is in danger of disappearing before the inroads of introduced animals like the rabbit, the sparrow, and the starling. The beginning of an attempt to stay this onset may be seen in the reservation in some of the States of asylums for the native animals. The Victorian reserve includes nearly all Wilson's Promontory, the southernmost part of Australia; New South Wales has reserved a coastal strip near the Hawkesbury mouth; but enlightened action is badly needed.

§ 7. The Flora of Australia.

1. **Character of the Australian Flora.**—(i.) *Effect of Climate and Altitude.* As would naturally be expected in a territory whose limits extend from the tropical latitudes of North Queensland to the temperate regions of Victoria and Tasmania, and whose physical elevation varies from the sea coast (or levels even below that of the sea) to peaks whose tops are covered during a great part of the year with snow, the vegetation of Australia is largely varied. In the Queensland tropics there are many forms which belong to the Malayan and Oceanic regions. In the north of Western Australia, the tropical area, comprising some 364,000 square miles, is lacking in these forms. The assertion of land contiguity between Northern Queensland and New Guinea and the Malayan Archipelago generally, frequently made by geologists and zoologists, is thus supported by botanical evidence. The existence of many types common to both Australia and South Africa points to the possibility of a land connection between those continents by way of what is now the Indian Ocean. But, whatever evidences of land connection may be discovered, the fact remains that the great bulk of the vegetation of the temperate zone, where the flora is profuse and various, is distinctively Australian. Hence Australia has been isolated for a long time, but probably not so long as New Zealand. The fact that the Australian flora is of a primitive type is of particular interest from a scientific point of view. Forms belonging to early stages in plant evolution exist upon this continent, which otherwise can only be studied as fossils in rocks of long-passed geological ages. This is seen particularly in *Byblis*, *Casuarina*, *Cephalotus*, *Nuytsia*, *Polypompholyx*, and *Phylloglossum*.

(ii.) *General Features of the Australian Landscape.* The coastal regions furnish the most luxuriant vegetation. A marked physical feature of the continent is the chain of mountain ranges which runs along part of the southern and the eastern coast, roughly parallel to the contour, and at little distance from the shore. Upon these heights, and on the uplands and foot-hills which stretch from them to the coast, is to be found the heaviest forest. There is, however, in Western Australia, also a great forest belt, some 350 miles in length, and from 50 to 100 miles in breadth, not on the coastal side but extending eastward from the Darling Ranges. Inland, from what may be called the coastal forest region, the vegetation becomes thinner as the more arid regions replace those of heavier rainfall, and rapidly dwindles, till bushes, scrubs, and dwarf eucalypts, with belts of pine at intervals, give place to a scant and inferior vegetation. Except in its south-west portion, Western Australia has little forest. South Australia has still less. But the great Australian mountain system runs from the Grampians of Western Victoria easterly, following generally the trend of the coast-line, north-easterly into New South Wales, and northerly through that State and Queensland to Cape York, with a spur which turns westward and forms the watershed between the streams which flow north into the Gulf of Carpentaria and those which eventually reach the Murray. Here there are large trees and dense undergrowth, very often giving place to rich pasture lands on the extensive plateaux and great plains that stretch away into the interior. Under the copious rainfall of the coastal regions the wild flowers that belong to Australia, variegated, bright, often scentless, grow luxuriously.

(iii.) *Special Plant Adaptations.* The general dryness of the climate of Australia has led to marked adaptations in form and structure especially in the interior parts of the continent. Spiny plants, with foliage of hard, woody ribs and reduced surface area, are characteristic. Exhalation into the air of the moisture absorbed from the soil by the roots, is thus reduced through the absence of soft cellular parts. The moisture absorbed by the root-system, scant because of the desert soil, is eagerly taken up by the arid atmosphere. In these, the relative amount of transpiring foliage is small, and appears to correspond to the soil conditions. Short, scale-like leaves, for example, mark considerable reduction in the foliage area. In the great majority of acacias, the true leaves are suppressed, the leaf stalks, however, remaining in a flat leaf-like form (*phyllodia*); or the leaf may be entirely suppressed, the leaf-functions being carried on by the stems of the plants. In some desert plants, as *Verbenaceæ* and *Solanaceæ*, a dense coat of hairs covers the leaves or whole plant; in others, as in some acacias, the surface of leaves and twigs is substantially a layer of resin, both modifications greatly reducing the transpiration, and serving also as a protection against the extremes of heat and cold to which they are subjected. Generally the vegetation on the west coast is more drought-resisting (*xerophilous*) than that on the east coast.

(iv.) *Forestry, Agriculture, and Horticulture.* Both hardwoods and softwoods abound in the forests, their commercial uses being set out in the chapter on Forestry (see Section X.) Among the exotics that have been acclimatised are many that yield valuable timber. Cereals are grown in large quantities, but none are indigenous. Native plants fit for human consumption are insignificant. Generally the indigenous plants that can be utilised for food need some preparation before being used. The part suitable for food is the yam-like root of some, the stems, foliage, or seeds of others. Useful fruits are found, but most of them require to be cooked, being very acid in their native state. In tropical Queensland there are pleasant fruits of the lime family. Edible species of fungi are also common, but none are marketed or much used, except the common mushroom. The aboriginals eat the fruits of the doobah (*Marsdenia Leichhardtiana*), the seeds of acacias, the grains of some indigenous grasses and of the nardoo (*Marsilia quadrifolia*), as well as other vegetable products having a more or less meagre store of nutriment. Many of the native grasses and other herbage have high nutritive properties, affording rich fodder, but there is not a native fodder clover; on the contrary, many native Leguminosæ are poisonous. The cultivation of native wildflowers, and the sporting of selected garden stocks, has led to the introduction of many new varieties, and horticulture is a growing industry.

2. **Botanic Distribution.**—(i.) *Tropical and Extra-tropical Regions.* The indigenous vegetation of Australia may be roughly classed as tropical and extra-tropical. The line of geographical distribution between the two classes is not distinctly marked, but it may be said that the former class covers the north-eastern uplands, where the Malayan and Oceanic forms have, by their incursion, enriched the east coast from Torres Straits as far south as Illawarra, and also the tropical regions of Western Australia, where the different climatic conditions and the absence of high mountains and the permanent streams and still waters usually associated with them do not cause the vegetation of these tropical latitudes to be specially distinguished. Extra-tropical plants, mostly hardwoods, characterise the Australian forests of temperate regions.

(*a*) *The North-east Tropical Vegetation.* While something under a tenth of Queensland bears timber of general commercial value, at least a third of that State may be said to be covered with trees which have a local use for building and other purposes. The vegetation is rich, the number and variety of plants being very large. There are a large number of fibrous plants of the orders *Malvaceæ*, *Sterculiaceæ*, *Leguminosæ*, *Urticaceæ*, *Scitamineæ*, *Amaryllideæ*, and *Aroideæ*. Of indigenous fruits the principal are the lime and Davidson's plum, with others of the order *Euphorbiaceæ*, *Ampelideæ*, *Rutaceæ*, and *Urticaceæ*. There are numerous fungi—many of them edible. Among trees, acacias, araucarias, xanthorrhœas, eucalypts, canariums and callitris are the most abundant. Besides these there are medicinal, oil, perfumery, rubber, and spice plants, as well as some which give tanning and dyeing material. Trees of many varieties, of unique beauty in the landscape, and yielding handsome timber for carpentry, cover the forests. Overlapping of the tropical and extra-tropical vegetation is inevitable, and the merging of the former into the latter becomes more and more marked after the New South Wales border is crossed. The vegetation of the north-east may be summarised by saying that between the Dividing Range and the Pacific there are some of the finest belts of forest in the continent. Among eucalypts are several varieties of ironbark (*Eucalyptus paniculata*, *E. crebra*, *E. siderophloia*, *E. sideroxylon*), tallow-wood (*E. microcorys*), blackbutt (*E. pilularis*), grey gum (*E. propinqua*), spotted gum (*E. maculata*), turpentine (*Syncarpia laurifolia*), forest red gum (*E. tereticornis*), and red mahogany (*E. resinifera*); among conifers, the Moreton Bay (*Araucaria Cunninghami*), brown (*Podocarpus elata*), and Bunya-Bunya (*Araucaria Bidwillii*) pines; while among the brush timbers of fine grain are red cedar (*Cedrela australis*), rosewood (*Dysoxylon Fraserianum*), red bean (*Dysoxylon Muelleri*), black bean (*Castanospermum australe*), white beech (*Gmelina Leichhardtii*), silky oak (*Grevillea robusta* and *Orites excelsa*), and tulipwood (*Harpulia pendula*). In Queensland, a large portion of the country west of the Divide is an extensive plateau running into great plains, but with little timber. Towards the centre of the continent, where the land gradually falls to a vast shallow basin, with low hilly ridges at intervals on its rim, and wide expanses of plain country with short water-courses losing themselves in the desert, the tree growth is very scanty, consisting chiefly of stunted eucalypts, such as the gimlet-gum (*E. salubris*) and black box (*E. microtheca*), the desert sheoak, acacias and mallee. Westward of the ranges in New South Wales, where the tableland sinks down to undulating country and vast plains, through which the tributaries of the Murray make their way, the vegetation changes to scrub and open forest, consisting of eucalypts such as red gum (*E. rostrata*) along the water-courses, with several varieties of box, cypress and other pines, and wattles. Farther inland again the timber becomes more sparse, being chiefly cypress pine, stunted eucalypts, and casuarianas, with extensive areas of mallee scrub.

(*b*) *The North-west Tropical Vegetation.* In the northern district of Western Australia, there are extensive tracts of pasture lands on the slopes drained by the rivers flowing into the Indian Ocean. Inland from these are stunted bush and scrub lands, which in some cases impinge even upon the sea border. The Kimberley district has forest country about the Fitzroy River, and the King Leopold Ranges are tree-clad. Farther eastward, and continuing across the border into the Northern Territory, grasses and stunted growths form the main vegetation. The flatness of the country accounts for the absence of mountain flora, the vertical elevation rarely reaching 1500 feet. The chief geological features are sandstone of the carboniferous era forming the tableland, and basaltic plains. As a consequence, the flora is very little varied, the largest order of plants being *Leguminosæ*, represented by acacias and cassias. The smaller plants include *Indigofera*, *Crotalaria*, *Daviesia*, and *Bossia*. Next to *Leguminosæ*, *Gramineæ*, of which there are several new types, are the most numerous. With the exception of the grasses, all the monocotyledons are limited. The *Myrtaceæ* include eucalypts (principally *E. rostrata*) and melaleucas. The *Loranthaceæ*, *Rubiaceæ*, *Cucurbitaceæ* and *Proteaceæ* are represented by several plants. *Compositæ*, *Chenopodiaceæ*, *Santalaceæ* and *Orchideæ* are rare, but members of the family *Lythraceæ* are more numerous than might have been expected. The Gymnosperms are sparingly represented, *Euphorbiaceæ* are surprisingly scarce. Perhaps the most marked characteristic of the whole tract is the almost entire absence of lichens and mosses, though ferns are plentiful in the vicinity of the Victoria River.

(c) *The Australian Extra-tropical Vegetation.* Australia is believed to have been free from geological upheavals and cataclysms for a longer period than most other lands. The persistence of type which has resulted has enabled its flora to become very well adapted to prevailing climatic conditions. The chief feature of the Australian forest landscape, as presented by the eastern, south-eastern, and south-western portions of the continent, is the presence of giant hardwoods, mostly eucalypts—very often rapidly reproductive, and attaining to a great age. The existing types are of high antiquity, and are possessed of special means of resistance to the extremes of temperature, to excessive sunshine, and to alternations of drought and flood to which they are subject. Along the shores of the Great Australian Bight, and in the north and north-west, there are no extensive forests. In the desert interior the vegetation is generally dwarfed and stunted, the forests of the inland slopes of the eastern mountains gradually thinning from the thickly-clad hilltops to second-class eucalypts, whilst these latter in turn give place to extensive areas of mallee scrub, the vegetation becoming more scarce, until in the arid interior, patches are found with no covering of herbage of any kind. The hill slopes, however, are often clad with rich grass, and along the water-courses eucalypts such as red gum persist, with pines and acacias. In the south-west, where the ranges approach closely to the ocean, the forest bed extends beyond the watershed some distance inland. The great belt of jarrah (*E. marginata*) which stretches eastward from the Darling Hills, has two distinct but narrow belts of tuart (*E. gomphocephala*) and red gum (*E. calophylla*) between it and the coast. Within this extensive tract of jarrah, in the extreme south-western part of the State, is the main karri (*E. diversicolor*) belt, stretching from Cape Hamelin to Torbay. In this region the jarrah, karri, tuart and red gum are the dominant trees. In the somewhat drier districts stretching eastward of the jarrah belt, there is a fairly wide strip of white gum (*E. redunca*) enclosing a narrow belt of York gum (*E. loxophleba*) which, as regards its northern and southern limits, is almost coterminous with the jarrah. Eastward of this again the arid region is entered, and the forest rapidly dwindles, changing first to a poorer growth of white gum until, in the sandy wastes of the goldfields region, the vegetation is scant and stunted, consisting chiefly of the eucalypts, locally known as salmon, morrell (*E. macrocarpa*), and gimlet (*E. salubris*) gums, with some belts of pines at intervals. The Tasmanian flora represents that of South-east Australia, but there are also some valuable conifers, chiefly in the western and southern parts, such as the Huon (*Dacrydium Franklini*), King William, and celery-top (*Phyllocladus rhomboidalis*) pines. The forest area of the island is extensive, covering two-thirds of its surface. The principal eucalypts are blue-gum (*E. globulus*), stringy-bark (*E. obliqua*), peppermint (*E. amygdalina*—the mountain ash of Victoria), and silver-top ironbark (*E. Sieberiana*); the chief fine-grain woods are blackwood (*Acacia melanoxylon*), beech or myrtle (*Fagus Cunninghami*), sassafras (*Atherosperma moschata*), native cherry (*Exocarpus cupressiformis*), native box (*Bursaria spinosa*), and casuarina or sheoak. These are distributed throughout the State.

The extra-tropical vegetation of Australia is highly differentiated from that of the rest of the world. In the eastern States, however, there is some admixture in the flora of species derived in the course of past ages from almost all other regions of the globe, but South and Western Australia are, as regards their flora, typically and purely Australian. The natural orders which are endemic, or nearly so, to Australia are either entirely confined to the continent or are represented elsewhere only by one or a few outlying species, mostly in adjoining regions. They are the *Tremandreæ*, *Stackhousiaceæ*, *Stylideæ*, *Goodeniaceæ*, *Casuarineæ*, *Philhydreæ*.

Like Australia, New Zealand has its own characteristic flora: 72 per cent. of its species are endemic, 21 per cent. are found also in Australia, and 7 per cent. are sub-antarctic. The forests are often mixed in their growths, with pines of various kinds generally predominating, the finest tree being the kauri pine (*Agathis australis*). Tawa (*Beilschmiedia tawa*) and totara (*Podocarpus totara*) also flourish. In the Middle Island several species of beech (*Nothofagus*) are found, particularly on the higher levels. In the forest areas there is dense undergrowth. In the meadows the tussock form is characteristic of various grasses and sedges. The shrub-form and the iris-like form also help to make up the facies. The scrub is made up to a large extent of manuka, which seems to be the same as our *Leptospermum scoparium*. *Bursaria spinosa* is common here as in the rest of Australia, this shrub being universal throughout Australia and New Zealand. *Pittosporum* is native to New Zealand.

(*d*) *Alpine Vegetation*. The Australian continent is not remarkably irregular in physical elevation, the highest elevation being only 7000 feet above sea level, while a great deal of the land surface stretches for many miles in extensive plains, offering no kind of relief to the eye. In these circumstances little characteristic alpine flora is to be expected. There is none in Western Australia, the vegetation on heights and plains having the same physiognomy. In Eastern and South-eastern Australia and New Zealand only the highest points of the mountains bear alpine flora. The transition from the forest to the alpine region is gradual, considerable overlapping of alpine and lowland flora being noticeable, and differentiation of alpine types is less marked than usual. Numerous bushes grow on these transition areas. Endemic conifers are wanting in the Australian Alps; but on many mountains which attain a height of 5000 feet the flowering plants display rich and varied colours.

(ii.) *Exotics*. While Australia has made large and flourishing additions to the forest flora of many countries, a large number of exotics have been successfully introduced here. furnishing a welcome variation to the sombre landscape presented by the prevailing eucalypts. With practically no cereals of value as food for man, and with few fodder plants, and these generally of an inferior kind, the fruits of the earth which Australia offered were indeed small. Now, however, her fields are sown with introduced grains and grasses, and yield abundantly. But alien weeds have come in too. Native pests are few in number, but some of the most aggressive weeds have intruded themselves, to the detriment of the native flora.

(iii.) *Persistence of Types.* Though there is every probability that individual varieties have been eliminated in the various terrestrial convulsions that have altered the land surface of this part of the globe, there is good reason for believing that Nature, "so careful of the type," has not suffered the eradication of representative forms. Nor has the hand of man, careless, in the strenuous days of early colonisation, in conserving the original vegetation, stamped out any of the indigenous species. That many places have been set aside for the preservation, as virgin country, of areas where the plant covering is yet undisturbed, attests a desire to render to botanic science that assistance which only forms belonging to an early stage of vegetation, such as the Australian, can afford.

3. **Natural Orders of Plants Represented in Australia.**—The following is a list of the natural orders of plants represented in Australia :—

CLASS I.—DICOTYLEDONS.

SUB-CLASS I.—POLYPETALÆ.

1. Ranunculaceæ
2. Dilleniaceæ
3. Magnoliaceæ
4. Anonaceæ
5. Menispermaceæ
6. Nymphæaceæ
7. Papaveraceæ
8. Cruciferæ
9. Capparideæ
10. Violarieæ
11. Bixineæ
12. Pittosporeæ
13. Tremandreæ
14. Polygaleæ
15. Frankeniaceæ
16. Caryophylleæ
17. Portulaceæ
18. Elatineæ
19. Hypericineæ
20. Guttiferæ
21. Malvaceæ
22. Sterculiaceæ
23. Tiliaceæ
24. Lineæ
25. Malpighiaceæ
26. Zygophyllaceæ
27. Geraniaceæ
28. Rutaceæ
29. Simarubæ
30. Burseraceæ
31. Meliaceæ
32. Olacineæ
33. Ilicineæ
34. Celastrineæ
35. Stackhousieæ
36. Rhamneæ
37. Ampelideæ
38. Sapindaceæ
39. Anacardiaceæ
40. Leguminosæ
    SUB-ORDERS:
    (i) Papilionaceæ
    (ii) Cæsalpineæ
    (iii) Mimosæ
41. Rosaceæ
42. Saxifrageæ
43. Crassulaceæ
44. Droseraceæ
45. Halorageæ
46. Rhizophoreæ
47. Combretaceæ
48. Myrtaceæ
49. Melastomaceæ
50. Lythrarieæ
51. Onagrarieæ
52. Samydaceæ
53. Passifloreæ
54. Cucurbitaceæ
55. Ficoideæ
56. Umbelliferæ
57. Araliaceæ
58. Cornaceæ
59. Loranthaceæ
60. Caprifoliaceæ
61. Rubiaceæ
62. Compositæ

SUB-CLASS II.—MONOPETALÆ.

63. Stylideæ
64. Goodenovieæ
65. Campanulaceæ
66. Ericaceæ
67. Epacrideæ
68. Plumbagineæ
69. Primulaceæ
70. Myrsineæ
71. Sapotaceæ
72. Ebenaceæ
73. Styracaceæ
74. Jasmineæ
75. Apocyneæ
76. Asclepiadeæ
77. Loganiaceæ
78. Gentianeæ
79. Hydrophyllaceæ
80. Boragineæ
81. Convolvulaceæ
82. Solaneæ
83. Scrophularineæ
84. Lentibularieæ
85. Orobanchaceæ
86. Gesneraceæ
87. Bignoniaceæ
88. Acanthaceæ
89. Pedalineæ
90. Myoporineæ
91. Selagineæ
92. Verbenaceæ
93. Labiatæ
94. Plantagineæ
95. Phytolaccaceæ
96. Chenopodiaceæ
97. Amarantaceæ
98. Paronychiaceæ
99. Polygonaceæ
100. Nyctagineæ
101. Myristiceæ
102. Monimiaceæ
103. Laurineæ
104. Proteaceæ
105. Thymeleæ
106. Elæagnaceæ
107. Nepenthaceæ
108. Euphorbiaceæ
109. Urticeæ
110. Casuarineæ
111. Piperaceæ
112. Aristolochiaceæ
113. Cupiliferæ
114. Santalaceæ
115. Balanophoreæ
116. Coniferæ
117. Cycadeæ

CLASS II.—MONOCOTYLEDONS.

118. Hydrocharideæ
119. Scitamineæ
120. Orchideæ
121. Burmanniaceæ
122. Irideæ
123. Amaryllideæ
124. Taccaceæ
125. Dioscorideæ
126. Roxburghiaceæ
127. Liliaceæ
128. Pontederaceæ
129. Philydraceæ
130. Xyrideæ
131. Commellinaceæ
132. Juncaceæ
133. Palmæ
134. Pandanaceæ
135. Aroideæ
136. Typhaceæ
137. Lemnaceæ
138. Naiadeæ
139. Alismaceæ
140. Eriocauleæ
141. Centrolepideæ
142. Restiaceæ
143. Cyperaceæ
144. Gramineæ

CLASS III.—ACOTYLEDONS (Non-flowering Vegetation).

145. Lycopodiaceæ
146. Marsileaceæ
147. Filices

§ 8. Climate and Meteorology of Australia.[1]

1. **History of Meteorology in Australia.**—Systematic rainfall observations appear to have been commenced first in Adelaide by the late Sir G. Kingston in 1839, and continued till 1878, the last eighteen years being concurrent with more complete observations taken at the Astronomical Observatory in that city. At Sydney, Port Macquarie, Melbourne, and Brisbane observations appear to have been taken from 1840. Those at Sydney from April, 1840, to the end of 1855 were taken at South Head, five miles east of Sydney; at Petersham in 1856, at Double Bay in 1857-8, and at the Sydney Observatory, Flagstaff Hill, from 1859 onwards.

At Brisbane a record of rainfall was kept from 1840 to 1846 by Captain T. C. Wickham. About 1860 Dr. Barton, Resident Surgeon of the Brisbane Hospital, continued the observations on the site occupied by the Supreme Court buildings, but upon his death the duties were transferred to the staff of the telegraph office, and the instruments removed to William-street. On the appointment of the first Government Meteorologist (Mr. E. MacDonnell) the instruments were again removed to Wickham Terrace, and some years later to the present site. Mr. C. L. Wragge succeeded Mr. MacDonnell in 1887.

At Hobart observations were started by Sir John Franklin, when Governor of Tasmania, in the year 1840. The Observatory was founded in the following year by Captain Kay, R.N., who took hourly observations for eight years. Mr. Francis Abbott, who had a private observatory in Murray-street, carried on tri-daily observations of pressure, temperature, humidity, cloud and rain from 1841 to 1880. Observations of rainfall were also started by the Marine Board at the lighthouses under their care, and by others privately. Mr. Abbott was obliged to relinquish his work in 1880. Captain Short was appointed Government Meteorologist in 1882.

Under the late Mr. R. L. J. Ellery, an Observatory was founded near Williamstown, Melbourne, in the middle of 1853, and a record also kept at Melbourne by Mr. Brough Smyth from 1856 till 1858, viz., to the date of the creation of the new Observatory on Flagstaff Hill under Professor Neumayer.

The observations at the present Melbourne Observatory were commenced in June, 1863, under Mr. R. L. J. Ellery himself, the Observatories at Williamstown and Flagstaff Hill being abandoned. At Port Phillip records were taken for the years 1840 till 1851, and are given in the New South Wales *Government Gazette.* Some doubt attaches to these records and to the site upon which they were taken; for this reason they have not been used in the discussion of rainfall for Melbourne itself, the results of which have been tabulated and given herein.

At Perth no official records of rainfall were taken till 1875, when the observations were commenced at the Botanical Gardens by the Surveyor-General (Sir Malcolm Fraser), and where they have been continued up to the present time. During the first half of last century meteorological observations were confined largely to rainfall only. Systematic observations of pressure, temperature, rainfall, wind, and other meteorological elements began with the foundation of the astronomical Observatories in the capitals of the different States, viz.:—At Adelaide in 1856; Hobart, 1841; Melbourne, 1854; and Sydney, 1858. The directors of these Observatories established meteorological stations, under competent observers, in different parts of the country from time to time, as opportunity allowed.

2. **Magnetic Observations.**—On the 1st January, 1841, an Imperial Observatory, forming part of an international scheme, was founded at "Hobart Town" (Tasmania), and magnetic observations were taken there systematically up to the end of 1854.

Early in 1858 Prof. Neumayer opened an Observatory on Flagstaff Hill, Melbourne, where hourly observations in terrestrial magnetism were taken regularly up to the 28th

1. Prepared from data supplied by the Commonwealth Meteorologist, H. A. Hunt, Esquire, F.R.M.S.

February, 1863. That gentleman also made extended trips into the country, where he determined the magnetic elements at 230 stations from sea-level to 7200 feet above, and distributed in such a manner that the greatest distance between them was not more than 30 miles, and frequently only 18 or 20 miles. By the commencement of February, 1864, Neumayer had completed his magnetic survey of Victoria. Since June, 1863, magnetic observations have been systematically continued at the Melbourne Observatory.

Observations in the other States, more or less fragmentary, have been carried on from time to time under the auspices of the Surveyor-General's Department.

3. **Equipment.**—The determination of the climatological data has been made by records from the following instruments :—

(i.) *Rainfall.* Rainfalls have been generally measured by the cylindrical gauge, 8 inches in diameter.

(ii.) *Temperature.* Temperatures have been recorded by self-registering maximum and minimum thermometers, which are read and set daily.

(iii.) *Atmospheric pressure.* Pressures have been measured by mercurial barometers of the Fortin or Kew pattern.

(iv.) *Evaporation.* The following description of tanks has been used in the observations of evaporation, viz.:—

PERTH.—Slate tank :—3 ft. by 3 ft. by 3 ft., inside a cement tank (sunk into the ground 2 ft. 6 in., leaving 5 in. clear all round) which is kept full of water.

ADELAIDE.—Slate tank :—3 ft. by 3 ft. by 3 ft., inside a cement tank (sunk into the ground, leaving 7 in. clear all round) which is kept full of water.

BRISBANE.—Piché's tube evaporimeter, from 1902 to 1906, that is, for five years only.

SYDNEY.—Galvanised iron tank, 4 ft. diameter and 3 ft. deep, sunk in the ground 2 ft. 11 in.

MELBOURNE.—Slate tank : – 3 ft. by 3 ft. by 10 in., sunk in ground and covered with wire cage 2 ft. above tank, $\frac{3}{4}$-in. wire netting.

4. **Wind Velocities and Pressures.**—The velocities have been measured by means of anemometers, of Robinson's pattern, at Perth, Adelaide, Sydney, and Melbourne, the sizes being as follows :—

Perth—Diameter of cups, 9 in. ; distance from centre to centre of cups, 4 ft.
Adelaide—Diameter of cups, $8\frac{1}{4}$ in. ; distance from centre to centre of cups, 4 ft.
Sydney—Diameter of cups, 4 in. ; distance from centre to centre of cups, 4 ft.
Melbourne—Diameter of cups, $8\frac{3}{8}$ in. ; distance from centre to centre of cups, 4 ft. $0\frac{1}{2}$ in.
At Hobart, Hagemann's suction tube was used.

The wind-pressures corresponding to the observed velocities have been calculated by the formula $P=0.003\ V^2$, in which P denotes pressure in lbs. per square foot, and V velocity in miles per hour.

5. **Creation of the Commonwealth Bureau of Meteorology.**—By Chapter 1, Part 5, Section 51, sub-section viii., of the Commonwealth Constitution it is enacted that "Parliament shall, subject to this constitution, have powers to make laws for the peace, order, and good government of the Commonwealth with respect to *inter alia* meteorological observations." The Meteorological Act of 1906 was assented to on the 28th August, 1906, and enacts that—The Commonwealth Meteorologist may, subject to the regulations and to the directions of the Minister, be charged with any of the following duties :—

(*a*) The taking and recording of meteorological observations.
(*b*) The forecasting of weather.
(*c*) The issue of storm warnings.
(*d*) The display of weather and flood signals.
(*e*) The display of frost and cold wave signals.

(*f*) The distribution of meteorological information.
(*g*) Such other duties as are prescribed to give effect to the provisions of this Act.

The Governor-General may enter into an arrangement with the Governor of any State in respect of all or any of the following matters :—

(*a*) The transfer to the Commonwealth, on such terms as are agreed upon, of any observatory and the instruments, books, registers, records, and documents used or kept in connection therewith.
(*b*) The taking and recording of meteorological observations by State officers.
(*c*) The interchange of meteorological information between the Commonwealth and State authorities.
(*d*) Any matters incidental to any of the matters above specified or desirable or convenient to be arranged or provided for for the purpose of efficiently and economically carrying out this Act.

The Governor-General may enter into any arrangement with the Governments of other countries or any of them for the interchange of meteorological information and any matter incidental thereto between such Governments and the Commonwealth.

The Governor-General may make regulations prescribing all matters necessary or desirable to be prescribed for carrying out or giving effect to this Act.

H. A. Hunt, Esquire, F.R.M.S., was appointed Commonwealth Meteorologist, and entered upon his duties on the 1st January, 1907.

6. **Meteorological Conference.** — Under the presidency of the Commonwealth Meteorologist, a conference of meteorologists was held in the Conference-room of the Bureau of Census and Statistics during the period from the 20th to the 23rd May, 1907, when the following questions were discussed, viz.:—

(i.) The range of practical meteorological observation to be at once undertaken.
(ii.) The expansion of meteorological work to be undertaken in the future.
(iii.) The extent of purely scientific investigations, the undertaking of which is desirable in the interests of meteorology.
(iv.) Meteorological records, reports, and publications.
(v.) Maritime meteorology.
(vi.) The relation of river observation to flood forecasting.
(vii.) The co-operation of the Commonwealth and States Departments.

7. **Organisation of Meteorological Bureau.**—The Central Bureau premises are situated at the corner of Victoria and Drummond streets, Carlton, Melbourne. Observations are carried on at this site, and also within the Royal Society's grounds, which afford a better exposure for the instruments. Divisional offices are also maintained in the capitals of each of the other States. The central Bureau is divided into five sub-departments, each being under the immediate supervision of assistants, whose duties are distributed as follows:—

Weather predictions, storm warnings, summaries of current weather, and management of the Central Bureau.

Divisional Bureaux and observing stations.

Climatological work and records of the Commonwealth.

Daily observations, entry of same into ledgers, reduction tables for various elements, distribution and collection of information with respect to the maritime branch of the service.

Instrumental stock, standardising and satisfactory working of all instruments before distribution to the observing stations throughout the Commonwealth.

The five assistants have been drawn from the different States, where they held leading positions in the meteorological services prior to the advent of federal control. They now constitute a daily forecast board, presided over by the Commonwealth Meteorologist. The observations made at the chief meteorological stations are telegraphed to the Central

Bureau, where they are plotted on charts and discussed by the Board. The results of its deliberations are then wired to the divisional Bureaux, where they are amplified or modified in the light of the latest local indications, and then distributed to the settled districts of the respective States.

8. **Publications, etc.**—The following have been issued daily, viz.:—(i.) Weather charts. (ii.) Rainfall maps. (iii.) Bulletins, Victorian and Interstate, shewing pressure, temperature, wind, rain, cloud extent, and weather.

The Bulletins of Climatology are as follows:—(i.) Bulletin No. 1.—A general discussion of the climate and meteorology of Australia, illustrated by one map and diagrams.

(ii.) Bulletin No. 2.—A discussion of the rainfall over Australia during the past ten years compared with the normal, illustrated by one map.

The daily observations made at all stations throughout the Commonwealth are being reduced to tabular form monthly with a view to publication at the end of the present year.

9. **General Description of Australia.**—In the general description of Australia, § 4.1. (i.), it is pointed out that a considerable portion (0.530) of three States of the Australian Commonwealth is north of the tropic of Capricorn, that is to say, within the States of Queensland, the Northern Territory and Western Australia, no less than 1,149,320[1] square miles belong to the tropical zone, and 1,020,720 to the temperate zone. The whole area of the Commonwealth within the temperate zone, however, is 1,825,261[2] square miles, thus the tropical part is about 0.386, or about five-thirteenths of the whole, or the "temperate" region is half as large again as the "tropical" (more accurately 1.509). By reason of its insular geographical position, and the absence of striking physical features, Australia is, on the whole, less subject to extremes of weather than are regions of similar area in other parts of the globe; and latitude for latitude Australia is, on the whole, more temperate.

The altitudes of the surface of Australia range up to a little over 7300 feet, hence its climate embraces a great many features, from the characteristically tropical to what is essentially alpine, a fact indicated in some measure by the name Australian Alps given to the southern portion of the great Dividing Range,

While on the coast the rainfall is often abundant and the atmosphere moist, in some portions of the interior the rainfall is very limited, and the atmosphere dry. The distribution of forest, as might be expected, and its climatic influence, is consequently very variable. In the interior there are on the one hand fine belts of trees, on the other there are large areas which are treeless, and where the air is hot and parched in summer. Again, on the coast, even as far south as latitude 35°, the vegetation is tropical in its luxuriousness and also somewhat so in character. Climatologically, therefore, Australia may be said to present a great variety of features. The various climatological characteristics will be referred to in detail.

10. **Meteorological Divisions.**—The Commonwealth Meteorologist has divided Australia, for climatological and meteorological purposes, into five divisions. The boundaries between these may be thus defined:—(*a*) between divisions I. and II., the boundary between South and West Australia, viz., the 129th meridian of east longitude; (*b*) between divisions II. and III., starting at the Gulf of Carpentaria, along the Norman River to Normanton, thence a straight line to Wilcannia on the Darling River, New South Wales; (*c*) between divisions II. and IV., from Wilcannia along the Darling River to its junction with the Murray; (*d*) between divisions II. and V., from the junction of the Darling and Murray Rivers, along the latter to Encounter Bay; (*e*) between divisions III. and IV., starting at Wilcannia, along the Darling, Barwon, and Dumaresq Rivers to the Great Dividing Range, and along that range and along the

1. In the article "Australia" in the Encyclopædia Britannica, Vol. XXX., p. 796, this area is given as 1,145,000 square miles.

2. Given as 1,801,700 square miles in the work above quoted, where, however, the statistics are said "to refer only to the continental States of the Federation, not to Tasmania."

watershed between the Clarence and Richmond Rivers to Evans Head on the east coast of Australia; (*f*) between divisions IV. and V., from the junction of the Darling and Murray Rivers along the latter to its junction with the Murrumbidgee, along the Murrumbidgee to the Tumut River, and along the Tumut River to Tumut, thence a straight line to Cape Howe; (*g*) division V. includes Tasmania.

The populations included within these boundaries on 30th June, 1907, may be taken approximately as follows:—

Division	I.	II.	III.	IV.	V.
Population	260,000	481,000	537,000	1,369,000	1,511,000

In these divisions the order in which the capitals occur is as follows:—(i.) Perth, (ii.) Adelaide, (iii.) Brisbane, (iv.) Sydney, (v.) Melbourne, (vi.) Hobart, and for that reason the climatological and meteorological statistics will be set forth in the indicated order in this publication.

(i.) *Special Climatological Stations.* The latitudes, longitudes, and altitudes of special stations, the climatological features of which are graphically represented hereinafter, are as follows:—

SPECIAL CLIMATOLOGICAL STATIONS.

Locality.	Height above Sea Level.	Latitude. S.		Longitude. E.		Locality.	Height above Sea Level.	Latitude. S.		Longitude. E.	
	Feet.	deg.	min.	deg.	min.		Feet.	deg.	min.	deg.	min.
Perth	197	31	57	115	51	Port Darwin ...	97	12	28	130	51
Adelaide ...	140	34	56	138	35	Daly Waters ...	700	16	16	133	23
Brisbane ...	137	27	28	153	2	Alice Springs ...	1926	23	38	133	37
Sydney	146	33	51	151	13	Dubbo ...	863	32	18	148	35
Melbourne ...	91	37	50	144	59	Laverton ...	1530	28	40	122	23
Hobart	160	42	52	147	22	Coolgardie ...	1402	30	57	121	10

11. **Temperatures.**—In respect of Australian temperatures generally it may be pointed out that the isotherm for 70° Fahrenheit extends in South America and South Africa as far south as latitude 33°, while in Australia it reaches only as far south as latitude 30°, thus shewing that, on the whole, Australia has a more temperate climate when compared latitude for latitude with places in the Southern Hemisphere.

The comparison is even more favourable when the Northern Hemisphere is included in the comparison, for in the United States the 70° isotherm extends in several of the western States as far north as latitude 41°. In Europe the same isotherm reaches almost to the southern shores of Spain, passing, however, afterwards along the northern shores of Africa till it reaches the Red Sea, when it bends northward along the eastern shore of the Mediterranean till it reaches Syria. In Asia nearly the whole of the land area south of latitude 40° N. has a higher isothermal value than 70°.

The extreme range of shade temperatures in summer and winter in a very large part of Australia amounts to probably only 81°. In Siberia, in Asia, the similar range is no less than 171°, and in North America 153°, or say nearly double of the Australian range.

Along the northern shores of the Australian continent the temperatures are very equable. At Port Darwin, for example, the difference in the means for the hottest and coldest months is only 8.7°, and the extreme readings for the year, that is, the highest maximum in the hottest month and the lowest reading in the coldest month, shew a difference of under 50°.

Coming southward the extreme range of temperature increases gradually on the coast, and in a more pronounced way inland.

The detailed temperature results for the several capitals of the States of Australia are shewn on the Climatological Tables hereinafter. It will suffice here to briefly refer to special features.

(i.) *Perth.* Meteorological observations were taken in the Perth Botanical Gardens as far back as 1876, but since the conditions surrounding the instruments and the situation of the station relative to Perth cannot be regarded as quite satisfactory, the more exact climate history of Perth did not properly commence until 1897, when the present Observatory was established. During the period 1897 to 1907, the mean annual shade temperature of Perth was 64°, about a degree higher than that for Sydney and Adelaide, over 5° higher than that for Melbourne, and 10° above that for Hobart, but, on the other hand, 4° below that for Brisbane. The average temperature for the month of January is 73.6°, and for July 55.2°.

The extreme maximum shade record of 107.9° was registered in December, 1904, and the lowest minimum shade temperature was 36.4°, viz., in July, 1906.

(ii.) *Adelaide.* In Adelaide the climate is drier and more sunny than in the other capitals, and, consequently, radiation is less hindered. The extremes of heat are consequently somewhat more marked, especially in the summer months. The mean shade temperature for January and February is 74.0°, and that of July 51.6°. Records of the temperature having reached 100° exist for each of the six summer months from October to March, and of having exceeded 110° exist for each of those months with the exception of March and October. The highest record of shade temperature in Adelaide is 116.3°, registered in January, 1858, and the lowest 32.2°, a range of 84.1°. The freezing point, although closely approached, has never actually been reached by the shade temperature thermometers, notwithstanding the fact that records have been kept for fifty-one years. Frosts have, however, occurred on the grass (four feet below the shade thermometers) at various times between the beginning of April and the end of November.

(iii.) *Brisbane.* In Brisbane the monthly mean shade temperature ranges from 77.3° in January to 58.0° in July, a difference of 19.3°. The extremes have varied from 108.9° in January to 36.1° in July, viz., through a range of 72.8°.

(iv.) *Sydney.* In Sydney the highest monthly mean is 71.5°, recorded in January, while the lowest, again in July, is 52.3°, giving a range of 19.2°.

The extremes of shade temperature recorded at Sydney over a period of nearly half a century are 108.5° in January, 1896, and 35.9° in July, 1890, *i.e.*, a range of 72.6°.

(v.) *Melbourne.* In Melbourne the January mean shade temperature averages 67.3°, and that of July 48.5°, the highest reading ever recorded being 111.2° in January, 1862, and the lowest 27.0° in July, 1869.

(vi.) *Hobart.* The mean temperature for the hottest month at Hobart is 62.0° in January and February, and that of the coldest 45.7°, the highest reading ever recorded being 105.2° in December, 1897, and the lowest 27.7°, nearly a degree higher than the lowest experienced in Melbourne.

(vii.) *Hottest and Coldest Parts.* A comparison of the temperatures recorded at coast and inland stations shews that, in Australia as in other continents, the range increases with increasing distance from the coast.

In the interior of Australia, and during exceptionally dry summers, the temperature occasionally reaches or exceeds 120° in the shade, and during the dry winters the major portion of the country to the south of the tropics is subject to ground frosts. An exact knowledge of temperature disposition cannot be determined until the interior becomes more settled, but from data procurable, it would appear that the hottest area of the continent is situated in the northern part of Western Australia about the Marble Bar and Nullagine goldfields, where the maximum shade temperature during the summer sometimes exceeds 100° for days, and even weeks continuously. The coldest part of the Commonwealth is the extreme south-east of New South Wales and extreme east of Victoria, namely, the region of the Australian Alps. Here the temperature seldom, if ever, reaches 100° even in the hottest of seasons.

In *Tasmania* also, although occasionally hot winds may cross the Straits and cause the temperature to rise to 100° in the low-lying parts, yet the island as a whole enjoys a most moderate and equable range of temperature throughout the year.

(viii.) *Monthly Maximum and Minimum Temperatures.* The mean monthly maximum and minimum temperatures can be best shewn by means of graphs, which exhibit the nature of the fluctuation for each for the entire year. In the diagram (on page 135) for nine representative places in Australia, the upper heavy curves shew the mean maximum, the lower heavy curves the mean minimum temperatures based upon daily observations. On the same diagram the thin curves shew the relative humidities (see next section).

12. **Relative Humidity.**—Next after temperature the degree of humidity may be regarded as of great importance as an element of climate; and the characteristic differences of relative humidity between the various capitals of Australia call for special remark. For nine representative places the variations of humidity are shewn on the preceding graph, which gives results based upon daily observations of the greatest and least humidity. Hitherto difficulties have been experienced in many parts of Australia in obtaining satisfactory observations for a continuous period of any length. For this reason it has been thought expedient to refer to the record of humidity at first order stations only, where the results are thoroughly reliable. Throughout the degree of humidity given will be what is known as *relative humidity*, that is, the percentage of aqueous vapour actually existing to the total possible if the atmosphere were saturated.

(i.) *Perth.* At Perth the mean annual humidity at 9 a.m. is 63; the greatest monthly mean is 83, and is in June, and the lowest 45, in January.

(ii.) *Adelaide.* At Adelaide the mean annual humidity is only 56; the mean monthly humidity has been as low as 33 in January and December, and as high as 84 in June.

(iii.) *Brisbane.* In Brisbane the mean annual humidity is 68; the lowest monthly mean recorded is 47, and is in September, and the highest 85 in the months of March and May.

(iv.) *Sydney.* In Sydney the mean annual humidity is 73; the greatest monthly average, which occurred in May, 1889, the wettest month on record during the last forty years, was 90, while the lowest monthly mean, 55, occurred in the month of October, 1867.

(v.) *Melbourne.* The mean annual humidity in Melbourne is 72; the greatest monthly average 88, in June and July, and the lowest 54, in February.

(vi.) *Hobart.* Hobart's mean annual humidity is 72, the highest 92, in June, and the lowest 51, in February.

From the above results, it is seen that, in respect of relative humidity, Sydney has the first place, while Hobart, Melbourne, Brisbane, Perth, and Adelaide follow in the order stated, Adelaide being the driest. The graphs on page 135 shew the annual variations in humidity. It will be observed that the *relative* humidity is ordinarily but not invariably great when the temperature is low.

13. **Evaporation.**—The rate and quantity of evaporation in any territory is influenced by the prevailing temperature, and by atmospheric humidity, pressure and movement. In

Australia the question is of perhaps more than ordinary importance; since in its drier regions water has often to be conserved in "tanks"[1] and dams. The magnitude of the economic loss by evaporation will be appreciated from the following records, which have been obtained from either jacketed tanks sunk into the ground, or from jacketed vessels exposed on the surface.

The average total evaporation at Sydney is 37.42 inches; at Melbourne, 38.33 inches; at Adelaide, 54.92 inches; and at Perth, 65.81 inches, these results being based respectively upon 46, 35, 38, and 9 years' observations. For Brisbane the result is 86.64 inches, based upon 5 years' observations only, and determined by means of Piché's tube evaporimeter.

In the interior of New South Wales the annual evaporation is as high as 84 inches; at Coolgardie, Western Australia, it was 85 inches in 1905, and at Laverton in the same year, 140.8 inches, or nearly 12 feet.

(i.) *Monthly Evaporation Curves.* The curves shewing the mean monthly evaporation in various parts of the Commonwealth will disclose how characteristically different are the amounts for the several months in different localities. The evaporation for characteristic places is shewn on diagram shewing also rainfalls (see page 136).

(ii.) In the interior of Australia the possible evaporation is often greater than the actual rainfall. Since therefore, the loss by evaporation depends largely on the exposed area, tanks and dams so designed that the surface shall be a minimum are advantageous. Similarly, the more protected from the direct rays of the sun and from winds, by means of suitable tree planting, the less will be the loss by evaporation: these matters are of more than ordinary concern in the drier districts of Australia.

14. **Rainfall.**—As even a casual reference to climatological maps, indicating the distribution of rainfall and prevailing direction of wind, would clearly shew, the rainfall of any region is determined mainly by the direction and route of the prevailing winds, by the varying temperatures of the earth's surface over which they blow, and by the physiographical features generally.

Australia lies within the zone of the south-east and westerly trade winds. The southern limit of the south-east trade strikes the eastern shores at about 30° south latitude. Hence we find that, with very few exceptions, the heaviest rains of the Australian continent are precipitated along the Pacific slopes to the north of that latitude, the varying quantities being more or less regulated by the differences in elevation of the shores and of the chain of mountains, upon which the rain-laden winds blow, from the New South Wales northern border to Thursday Island. The converse effect is exemplified on the north-west coast of Western Australia from the summer south-east trade winds. Here the prevailing winds, blowing from the interior of the continent instead of from the ocean, result in the lightest coastal rain in Australia.

The westerly trade winds, which skirt the southern shores, are responsible for the very reliable, although generally light, rains enjoyed by the south-western portion of Western Australia, by the south-eastern agricultural areas of South Australia, by a great part of Victoria, and by the whole of Tasmania.

(i.) *Factors determining Distribution and Intensity of Rainfall.* The distribution and intensity of rainfall in the interior of the continent, and also to some extent in the areas already mentioned, are governed by the seasonal peculiarities of three distinct atmospheric control systems, the most important of which is, undoubtedly, the anti-

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1. In Australia artificial storage ponds or reservoirs are called "tanks."

cyclonic stream. This stream, which girdles the earth and embraces approximately the region between 15° and 40° south latitude, breaks up into vast elliptically-shaped bodies of circulating atmosphere, measuring frequently 3000 miles in their major and 2000 miles in their minor axes. In passing over Australia from west to east, these great bodies of circulating air cause moist-laden winds to sweep across the continent from the surrounding oceans. The front-circulation brings in winds from the Southern Ocean, and the rear-circulation those from the equatorial seas.

The rain-invoking agent second in order of importance because of its reliability is the well-known "V-shaped depression." The sphere of operation of this latter disturbance is ordinarily the southern half of the continent, although occasionally it may extend its influence to tropical latitudes. The western half of this type of disturbance, with a southerly wind circulation, is the portion from which rain is most frequently to be expected, but occasionally good falls of rain, attended with electrical manifestations, are liberated from the warm eastern portion.

The third agent associated with the production of rain is the tropical depression more popularly known as the "monsoonal depression." This disturbance may be in active evidence for a succession of seasons, and then be conspicuously absent for a number of years, thus raising the question whether, after all, it can be regarded as in any way a distinctive feature of Australian meteorology.

When these disturbances are actively operative in the production of rain, the effect on the country generally, and the economic results for the succeeding season, are very pronounced. The interior of the continent becomes transformed. The plains, which ordinarily have so profound an effect on the heat winds of the summer, are deluged with rain, and respond immediately with an astonishingly luxurious growth of grass and herbage. The air is both tempered in heat, and loses its dryness for considerable periods after their visitations.

The distribution of rain by monsoonal disturbances is, however, very capricious in comparison with that precipitated by the southern "depressions." During some seasons the whole of the northern half of the continent will benefit to a fairly uniform degree, at another time some special region will be favoured. A remarkable example of this peculiarity occurred in 1902, for when monsoonal rains were copiously falling over the major portion of Western Australia, the eastern half of the continent was suffering from severe drought conditions.

During other seasons, tongue-shaped regions extending southwards from the northern shores of the continent will be particularly favoured in regard to rain. These regions may extend to the interior of Western Australia, and simultaneously others may occur in the Central Territory, in Western Queensland, and in the interior of New South Wales.

It is thus obvious that different parts of the continent are mainly dependent upon forms of atmospheric disturbances for what may be called their fundamental rains, and since there is a seasonal tendency for a particular class of storms to predominate, it rarely happens that any year passes without a good rain being universally enjoyed. Again, the condition of drought can hardly affect the whole of the continent at the same time. Nevertheless a more than ordinarily fortunate condition in one part of the continent ordinarily implies drought conditions in another, or *vice-versâ*. Thus in New South Wales, monsoonal rains, so beneficial to its north-western districts, rarely extend during the same season to coastal areas, or to Southern Riverina. For this reason it may happen occasionally that sheep may with advantage be sent 500 or 600 miles from the coast for feed and water. Should the southern or antarctic low-pressures be the predominating influence, the country to the south of the Murrumbidgee River is benefiting at the expense of the remainder of the State.

Good coastal season ordinarily depends upon an anticyclonic control; when such exists, the country west of the tablelands usually wants water.

A good season for Australia as a whole is dependent upon many circumstances. Not only must the main rain-giving storms be well represented, but other favourable conditions must also coexist. The general rate of translation of the atmosphere across the continent is a factor of the utmost importance. Another is the latitude the cyclones and anti-cyclones are moving in, and, further, the daily or periodic surgings of high and low pressures to and from the equator are also factors of considerable moment.

(ii.) *Time of Rainfall.* Monsoonal rains affect the northern parts of the continent in December or January, and may continue with diminishing energy for nearly six months of the year. As they penetrate into higher latitudes the period of action is delayed, but is not shortened, though the quantities of the fall materially lessen. Antarctic rains are experienced during the winter months of the year, the resultant quantities being reliable and consistently regular. The heaviest totals from this source are precipitated on the west coast of Tasmania. Thus at Queenstown the total for one year exceeded 140 inches, and even the average is 127.81 inches.

Anti-cylonic rains occur at all times of the year, but more markedly from March to September. They benefit particularly the southern area of the continent, and are responsible for many of the heaviest rainfalls and floods on the coastal districts of New South Wales.

(iii.) *Wettest and Driest Regions.* The wettest place in Australia is Geraldton, on the north-east coast of Queensland, where the average rainfall is no less than 145 inches, the maximum yearly total being 211.24 inches and the minimum 69.87 inches. The difference of range between these extremes is 141.37 inches.

The driest known part of the continent is about the Lake Eyre district in South Australia (the only part of the continent below sea level), where the annual average is but 5 inches, and where it rarely exceeds 10 inches for the twelve months.

The inland districts of Western Australia have until recent years been regarded as the driest part of Australia, but authentic observations taken during the past decade at settled districts in the east of that State shew that the annual average is from 10 to 12 inches.

(iv.) *Quantities and Distribution of Rainfall generally.* The departure from the normal rainfall increases greatly and progressively from the southern to the northern shores of the continent, and similarly also at all parts of the continent, subject to capricious monsoonal rains, as the comparisons hereunder will shew. The general distribution is best seen from the map on page 138, shewing the areas subject to average annual rainfalls lying between certain limits. The areas so defined are shewn in the following table:—

DISTRIBUTION OF AVERAGE RAINFALL.

Average Annual Rainfall.	N.S.W.	Victoria.	Queensland.	South Aust.	Northe'n Territ'y.	Western Aust.	Tasmania.	Commonwealth.
	sqr. mls.	sqr. mls.	sqr. mls.	sqr. mls.	sqr. mls.	sqr. mls.	sqr. mls.	sqr. mls.
Under 10 inches	81,144	nil	135,600	306,663	6,300	408,300	nil	938,007
10—20 ,,	116,363	36,300	255,300	57,935	213,430	400,720	nil	1,080,048
20—30 ,,	77,910	27,900	173,400	13,908	96,790	113,700	11,395	515,003
30—40 ,,	20,414	18.770	58,700	1,198	120,600	39,100	5,396	264,178
Over 40 ,,	14,541	4,914	47,500	366	86,500	14,100	9,424	177,345
Total area ...	310,372	87,884	670,500	380,070	523,620	975,920	26,215	2,974,581

Referring first to the southern capitals, it may be noted that the average at Melbourne from authentic records is 25.57 inches; the maximum 44.25, and minimum 15.61; the range therefore is 28.64 inches. At Adelaide the average determined from sixty-eight years' totals is 20.88, the maximum 30.87, the minimum 13.43, and the range therefore 17.44 inches. At Hobart 23.53 inches is the average annual rainfall, 40.67 is the highest total for one year, 13.43 is the lowest; thus 27.24 inches is the extreme range. The average for Perth is 33.18 inches, 46.73 being the maximum and 20.48 inches the minimum; the range is therefore 26.25 inches. These figures appear to constitute an exception to the general rule, but it should be mentioned as a possible explanation that records have there been taken only since 1876, whereas the records at the other cities date from 1840 or thereabouts.

Continuing the comparison of rainfall figures, Sydney's average annual total is 48.54 inches, its maximum 82.81 in 1860, and minimum 21.48 in 1849, thus the range is 61.33 inches. At Brisbane the disparities are greater still. There the average is 48.44 inches —a trifle lower than that of Sydney—the annual maximum was 88.26 inches in 1893, the minimum 16.17 inches in 1902, and the range therefore 62.09 inches.

In order to shew how the rainfall is distributed throughout the year in various parts of the continent, the figures of representative towns have been selected. Port Darwin, typical of the Northern Territory, shews that in that region nearly the whole of the rainfall occurs in the summer months, while little or nothing falls in the middle of the year. The figures of Perth, as representing the south-western part of the continent, are the reverse, for while the summer months are dry, the winter ones are very wet. In Melbourne and Hobart the rain is fairly well distributed throughout the twelve months, with a maximum in October in the former, and in November in the latter. The records at Alice Springs and Daly Waters indicate that in the central parts of Australia the wettest months are in the summer and autumn. In Queensland, as in the Northern Territory, the heaviest rains fall in the summer months, but good averages are also maintained during the other seasons.

On the coast of New South Wales, the first six months of the year are the wettest, with slight excesses in April and July; the averages during the last six months are fair and moderately uniform. In general it may be said that one-fourth of the area of the continent, principally in the eastern and northern parts, enjoys an annual average rainfall of from 20 to 50 inches, the remaining three-fourths receiving generally from 10 to 15 inches.

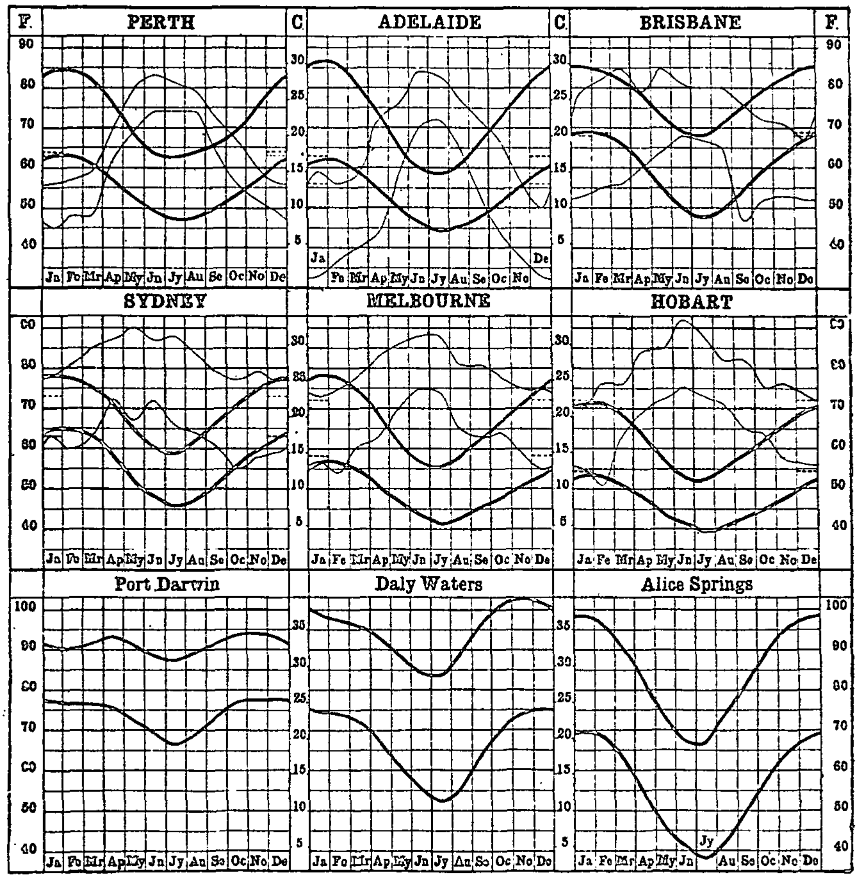
(v.) *Curves of Rainfall and Evaporation.* The relative amounts of rainfall and evaporation at different times through the year are best seen by referring to the graphs for a number of characteristic places. It will be recognised at once how large is the evaporation when water is fully exposed to the direct rays of the sun, and to wind, etc.

(vi.) *Tables of Rainfall.* The table of rainfall for a long period of years for each of the various Australian capitals, affords information as to the variability of the fall in successive years and the list of the more remarkable falls furnishes information as to what may be expected on particular occasions.

RAINFALL AT THE AUSTRALIAN CAPITALS.

Year.	Perth.			Adelaide.			Brisbane.			Sydney.			Melbourne.			Hobart.		
	Amount.	No. of Days.	10 Years' Means.	Amount.	No. of Days.	10 Years' Means.	Amount.	No. of Days.	10 Years' Means.	Amount.	No. of Days.	10 Years' Means.	Amount.	No. of Days.	10 Years' Means.	Amount.	No. of Days.	10 Years' Means.
	in.		in.	in.		in.	in.		in.	in.		in.	in.		in.	in.		in.
1840	...	...	...	24.23	99	...	29.32	...	...	58.52	150	...	22.57	...	...	...	...	...
1	...	...	...	17.96	93	...	49.31	...	...	76.31	142	...	30.18	...	...	13.95	...	...
2	...	...	...	20.32	122	...	28.82	...	...	48.82	137	...	31.16	...	...	23.60	...	...
3	...	...	...	17.19	104	...	51.23	...	...	62.78	168	...	21.54	...	...	13.43	...	...
4	...	...	...	16.88	136	...	63.21	...	...	70.67	157	...	30.74	...	...	26.25	...	...
5	...	...	...	18.83	125	...	39.19	...	...	62.03	132	...	23.93	...	...	16.68	...	...
6	...	...	...	26.89	114	...	31.43	...	41.79 (7 yr.)	43.83	139	60.42 (7 yr.)	30.53	...	27.24 (7 yr.)	21.96	...	...
7	...	...	...	27.61	109	21.24 (8 yr.)	...	...	...	42.80	142	...	30.18	...	...	14.46	...	18.62 (7 yr.
8	...	...	...	19.74	114	...	42.59	...	...	59.17	137	...	33.15	...	...	23.62	...	...
9	...	...	...	25.44	110	...	...	...	...	21.48	140	...	44.25	...	...	33.51	...	...
1850	...	...	...	19.56	84	...	...	...	...	44.88	157	...	26.98	...	...	14.51	...	...
1	...	...	...	30.86	128	...	...	...	...	35.14	142	...	...	...	...	17.98	...	...
2	...	...	...	27.44	118	...	...	...	...	43.78	145	...	...	...	...	23.62	...	...
3	...	...	...	27.08	128	...	...	...	...	46.11	130	...	...	...	...	14.53	...	...
4	...	...	...	15.35	105	...	...	...	...	29.28	136	...	...	...	...	30.56	...	...
5	...	...	...	23.15	124	...	...	...	...	52.85	138	...	28.21	...	...	18.25	131	...
6	...	...	...	24.93	118	...	...	...	...	43.31	116	...	29.75	134	...	22.73	152	...
7	...	...	...	21.15	105	23.57	...	...	...	50.95	135	42.76	28.90	138	...	17.14	113	21.65
8	...	...	...	21.55	107	...	43.00	...	...	39.60	139	...	26.01	158	...	33.07	129	...
9	...	...	...	14.85	95	...	35.00	...	...	42.06	128	...	21.82	156	...	23.31	159	...
1860	...	...	...	19.67	119	...	54.63	144	...	82.81	182	...	25.38	133	...	21.05	142	...
1	...	...	...	24.04	147	...	69.44	155	...	58.36	157	...	29.16	159	...	28.19	...	...
2	...	...	...	21.85	119	...	28.27	98	...	23.98	111	...	22.08	139	...	21.72	...	...
3	...	...	...	23.68	145	...	68.82	146	...	47.08	152	...	36.42	165	...	40.67	...	...
4	...	...	...	19.75	121	...	47.00	114	...	69.12	187	..	27.40	144	...	28.11	...	...
5	...	...	...	15.51	108	...	24.11	52	...	36.29	128	...	15.94	119	...	23.07	...	...
6	...	...	...	20.11	116	...	51.18	142	...	36.81	149	...	22 41	107	...	23.55	...	...
7	...	...	...	19.05	112	20.01	61.04	112	48.25	59.68	126	49.58	25.79	133	25.24	22.27	...	26.50
8	...	...	...	19.99	113	...	35.98	110	...	43.05	127	...	18.27	120	...	19.08	...	...
9	...	...	...	14.74	117	...	54.39	114	...	48.19	134	...	24.58	129	...	23.87	...	...
1870	...	...	...	23.84	119	...	79.06	154	...	64.22	178	...	33.77	129	...	27.53	...	...
1	...	...	...	23.25	137	...	45.45	119	...	52.27	141	...	30.17	125	...	18.25	...	...
2	...	...	...	22.66	146	...	49.22	131	...	37.12	161	...	32.52	136	...	31.76	...	...
3	...	...	...	21.00	139	...	62.02	138	...	73.40	176	...	25.60	134	...	23.43	...	...
4	...	...	...	17.23	127	...	38.71	135	...	63.60	173	...	28.10	134	...	24.09	...	...
5	...	...	...	29.21	157	...	67.03	162	...	46.25	153	...	32.87	158	...	29.25	...	...
6	28.73	100	...	13.43	110	...	53.42	130	...	45.69	156	...	24.04	134	...	23.63	...	...
7	20.48	103	...	24.95	135	21.03	30.28	119	51.56	59.66	147	53.35	24.10	124	27.40	20.82	...	24.07
8	39.72	143	...	22.08	112	...	56.33	134	...	49.77	129	...	25.36	116	...	29.76	...	...
9	41.34	106	...	20.69	130	...	67.30	157	...	63.19	167	...	19.28	127	...	21.07	...	...
1880	31.79	116	...	22.48	142	...	49.12	134	...	29.51	142	...	28.48	147	...	25.05	...	...
1	24.78	101	...	18.02	135	...	29.39	117	...	41.09	163	...	24.08	134	...	22.09	...	...
2	35.68	109	...	15.70	134	...	42.62	121	...	42.28	112	...	22.40	131	...	30.30	...	...
3	39.65	122	...	26.76	161	...	32.22	114	...	46.92	157	...	23.71	130	...	24.04	...	...
4	31.96	92	...	18.74	138	...	43.49	136	...	44.04	159	...	25.85	128	...	21.55	171	...
5	33.44	110	...	15.89	133	...	26.85	112	...	39.91	145	...	26.94	123	...	28.29	176	...
6	28.90	89	...	14.42	141	...	53.66	152	...	39.43	152	...	24.00	128	...	21.39	...	...
7	37.52	105	34.48	25.70	164	20.05	81.54	238	48.25	60.16	189	45.63	32.39	153	25.25	24.21	174	24.78
8	27.83	117	...	14.55	131	...	33.08	143	...	23.01	132	...	19.42	123	...	18.45	151	...
9	39.96	123	...	0.87	143	...	49.36	155	...	57.16	186	...	27.14	125	...	30.80	180	...
1890	46.73	126	...	25.78	139	...	73.02	162	...	81.42	184	...	24.20	140	...	27.51	173	...
1	30.33	93	...	14.01	113	...	41.68	143	...	55.30	200	...	26.73	126	...	23.25	160	...
2	31.23	122	...	21.53	137	...	64.97	145	...	69.26	189	...	24.69	124	...	17.17	...	...
3	40.12	145	...	21.49	129	...	88.26	147	...	49.90	208	...	26.80	140	...	27.46	146	...
4	23.72	103	...	20.78	134	...	44.02	143	...	38.22	188	...	22.60	138	...	27.39	151	...
5	33.01	123	...	21.28	130	...	59.11	105	...	31.86	170	...	17.04	131	...	19.93	121	...
6	31.50	103	...	15.17	121	...	44.97	121	...	42.40	157	...	25.16	124	...	20.87	135	...
7	27.25	101	33.17	15.42	119	20.09	42.53	115	54.10	42.52	136	49.11	25.85	117	23.96	20.45	153	23.33
8	32.04	109	...	20.75	116	...	60.60	131	...	43.17	149	...	15.61	102	...	20.40	164	...
9	31.96	104	...	18.84	119	...	37.35	137	...	55.90	172	...	28.87	116	...	20.68	166	...
1900	36.25	116	...	21.68	133	...	34.41	110	...	66.54	170	...	28.09	139	...	19.13	136	...
1	35.84	118	...	18.01	124	...	38.48	110	...	40.10	151	...	27.45	113	...	23.68	147	...
2	26.52	89	...	16.02	123	...	16.17	87	...	43.07	176	...	23.08	102	...	21.90	150	...
3	35.45	139	...	25.47	134	...	49.27	136	...	38.62	169	...	28.43	130	...	25.85	139	...
4	34.62	118	...	20.31	117	...	33.23	124	...	45.93	155	...	29.72	128	...	22.40	139	...
5	34.00	101	...	22.28	131	...	36.76	108	...	35.03	144	...	25.64	129	...	32.08	168	...
6	31.51	112	...	26.51	127	...	42.84	125	...	31.89	159	...	22.29	114	...	23.28	155	...
7	37.91	132	33.61	17.78	125	20.76	31.45	119	38.06	31.32	132	43.16	22.26	106	25.14	25.92	167	23.53
Mns.			33.18			20.88			48.44			48.54			25.57			23.71
No. of Yrs.			(32)			(68)			(58)			(68)			(64)			(67)

GRAPHS SHEWING ANNUAL FLUCTUATIONS OF MEAN MAXIMUM AND MINIMUM TEMPERATURE AND HUMIDITY IN SEVERAL PARTS OF THE COMMONWEALTH OF AUSTRALIA.



EXPLANATION OF THE GRAPHS OF TEMPERATURE AND HUMIDITY.—In the above graphs, in which the heavy lines denote 'temperature' and the thin lines 'humidity,' the fluctuations of mean temperature and mean humidity are shewn throughout the year. These curves are plotted from the data given in the Climatological Tables hereinafter. The temperatures are shewn in degrees Fahrenheit, the inner columns giving the corresponding values in centigrade degrees. Humidities have not been obtained for Port Darwin, Daly Waters, or Alice Springs.

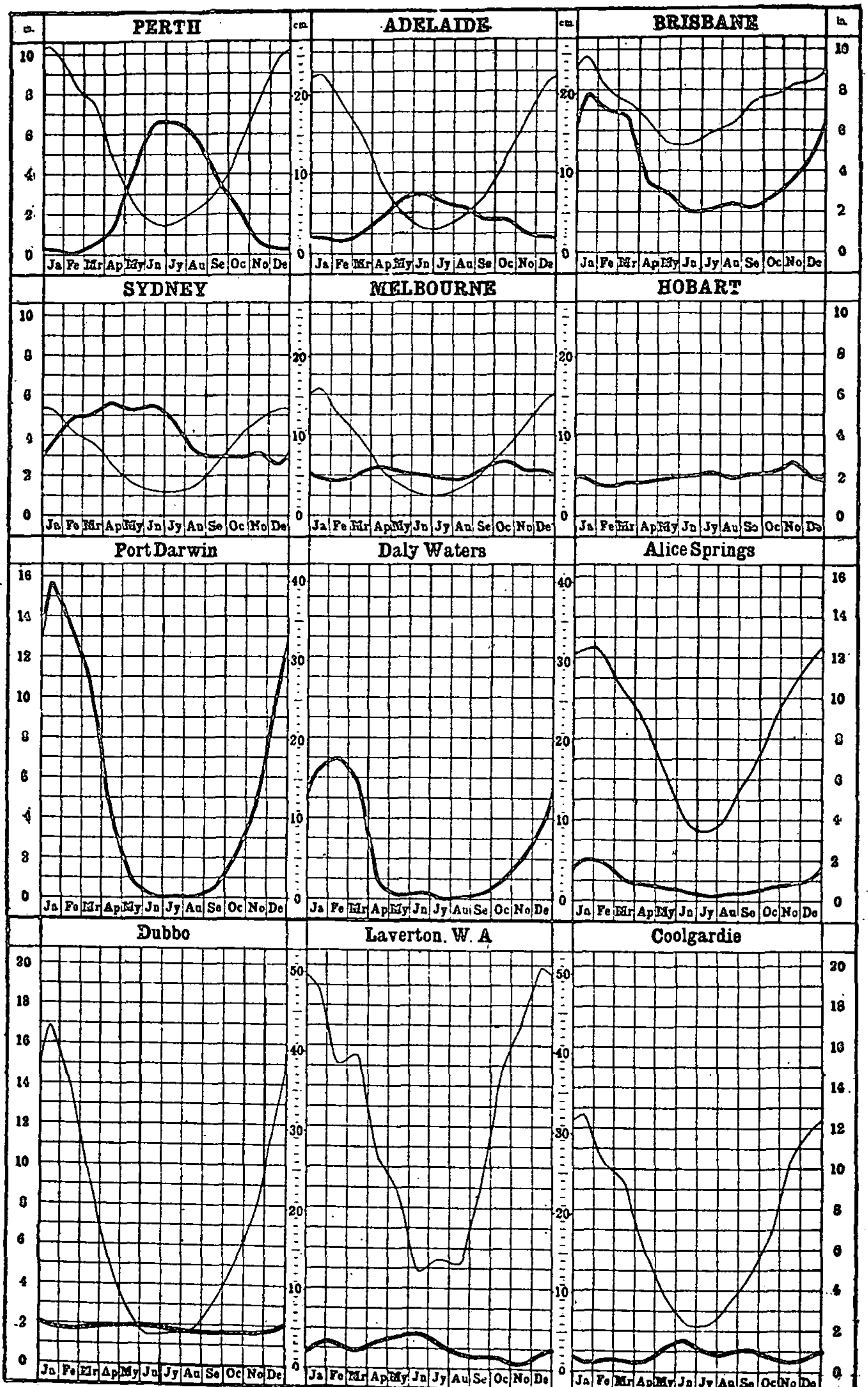
For the thin lines the degree numbers represent relative humidities, or the actual percentages of actual saturation on the total for the respective temperature.

In both cases the upper line represents the mean of the maximum, and the lower line the mean of the minimum results; thus the curves also shew the progression of the range between maximum and minimum temperatures throughout the year.

INTERPRETATION OF THE GRAPHS.—The curves denote mean monthly values. Thus, taking, for example, the temperature graphs for Perth, the mean readings of the maximum and minimum temperatures for a number of years on 1st January would give respectively about 83° Fahr. and 62° Fahr. Thus the mean range of temperature on that date is the difference, viz., 21°. Similarly, observations about 1st June would give respectively about 66° Fahr. and 51° Fahr., or a range of 15°.

In a similar manner it will be seen that the mean of the greatest humidities, say on 31st March, is about 64 and the mean of the least humidities 55; in other words, at Perth, the degree of saturation of the atmosphere by aqueous vapour ranges on 31st March between 64 % and 55 %.

GRAPHS SHEWING ANNUAL FLUCTUATIONS OF MEAN RAINFALL AND MEAN EVAPORATION IN SEVERAL PARTS OF THE COMMONWEALTH OF AUSTRALIA.



(For explanation see next page.)

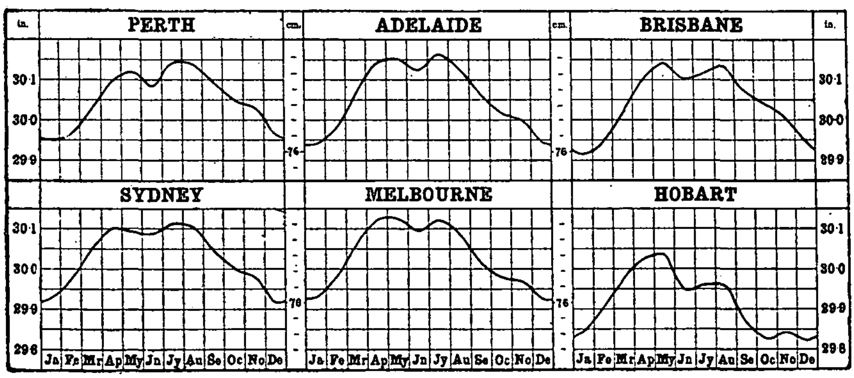
EXPLANATION OF THE GRAPHS OF RAINFALL AND EVAPORATION.—On the preceding graphs thick lines denote rainfall and thin lines evaporation, and shew the fluctuation of the mean rate of fall *per month* throughout the year. The results, plotted from the Climatological Tables hereinafter, are shewn in inches (see the outer columns), and the corresponding metric scale (centimetres) is shewn in the two inner columns. The evaporation is not given for Hobart, Port Darwin, nor Daly Waters.

INTERPRETATION OF THE GRAPHS.—The distance for any date from the zero line to the curve, represents the average number of inches, reckoned as per month, of rainfall at that date. Thus, taking the curves for Adelaide, on the 1st January the rain falls on the average at the rate of about four-fifths of an inch per month, or, say, at the rate of about 9½ inches per year. In the middle of June it falls at the rate of nearly 3 inches per month, or, say, at the rate of about 36 inches per year. At Dubbo the evaporation is at the rate of nearly 17 inches per month about the middle of January, and only about 1¼ inches at the middle of June.

TABLE SHEWING MEAN ANNUAL RAINFALL AND EVAPORATION IN INCHES OF THE PLACES SHEWN ON PRECEDING PAGE, AND REPRESENTED BY THE GRAPHS.

—	Rainfall.	Evaporation.	—	Rainfall.	Evaporation.
Perth ...	33.03	65.70	Port Darwin ...	61.55	—
Adelaide ...	20.89	54.97	Daly Waters ...	27.14	—
Brisbane ...	47.47	86.64	Alice Springs...	10.78	97.88
Sydney ...	48.80	37.42	Dubbo ...	22.23	81.03
Melbourne ...	26.35	38.33	Laverton, W.A.	10.76	—
Hobart ...	23.38	—	Coolgardie ...	8.88	83.58

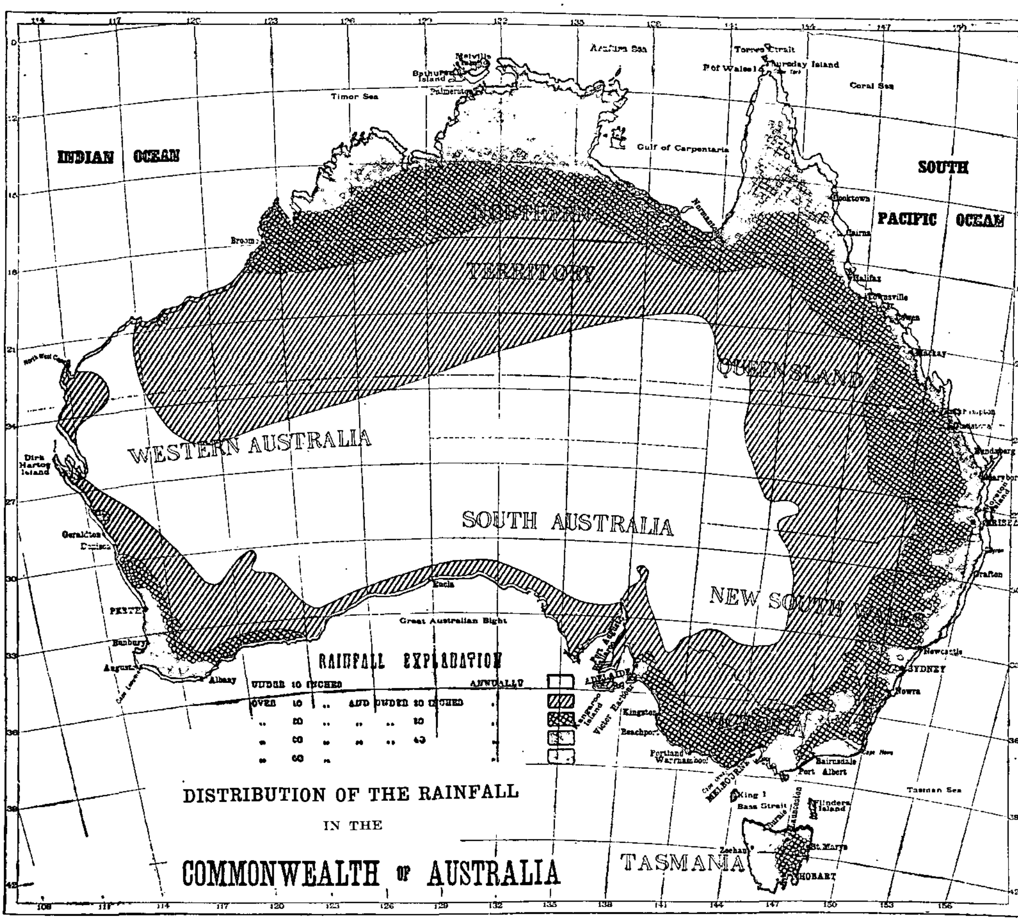
GRAPHS SHEWING ANNUAL FLUCTUATIONS OF MEAN BAROMETRIC PRESSURE FOR THE CAPITALS OF THE COMMONWEALTH OF AUSTRALIA.



EXPLANATION OF THE GRAPHS OF BAROMETRIC PRESSURE.—On the above graphs the lines representing the yearly fluctuation of barometric pressure at the capital cities are means for long periods, and are plotted from the Climatological Tables given hereinafter. The pressures are shewn in inches on about 2⅝ times the natural scale, but the corresponding pressures in centimetres are also shewn in the two inner columns, each division representing one millimetre.

INTERPRETATION OF THE BAROMETRIC GRAPHS.—Taking the Brisbane graph for purposes of illustration, it will be seen that the mean pressure on 1st January is about 29.93 inches, and there are maxima in the middle of May and August of about 30.15 and 30.14 respectively. The double maxima appear clearly on each graph.

RAINFALL OF AUSTRALIA.



The above map has been prepared from a chart shewing the isohyets (curves of equal mean annual rainfall) for every 10 inches for Australia, and compiled from the most recent information. It was impracticable on the small scale map to distinguish between the areas with 40 to 50, 50 to 60, 60 to 70, and over 70 inches of rain annually.

15. **Remarkable Falls of Rain.**—The following are the more remarkable falls of rain in the States of Western Australia, South Australia, Queensland, and New South Wales :—

HEAVY RAINFALLS, NEW SOUTH WALES, UP TO 1907, INCLUSIVE.

Name of Town or Locality.	Date.	Amnt.	Name of Town or Locality.	Date.	Amnt.
		ins.			ins.
Albion Park ...	8 Feb., 1895	10.00	Kempsey	10 Mar., 1893	10.34
Albury	14 ,, 1898	10.70	Leconfield... ...	9 ,, ,,	14.53
Alme Dorrigo ...	22 Jan., 1893	10.27	Liverpool	23 Feb., 1874	10.39
Anthony	28 Mar., 1887	17.14	Maitland W. ...	9 Mar., 1893	14.79
,, ...	15 Jan., 1890	13.13	Major's Creek ...	14 Feb., 1898	12.32
Arnold Grove ...	28 May, 1889	11.13	Mittagong... ...	6 Mar., 1893	11.71
,, ,, ...	20 Mar., 1892	10.08	Morpeth	9 ,, ,,	21.52
Araluen	14 Feb., 1898	10.51	Mount Kembla ...	14 Feb., 1898	10.25
,, ...	15 ,, ,,	13.36	Myra Vale ...	14 ,, ,,	10.00
Billambil	14 Mar., 1894	12.94	Nambucca Heads ...	3 Apr., 1905	10.62
Bowral	6 ,, 1893	11.94	Nepean Tunnel ...	14 Feb., 1898	12.30
Bowraville... ...	22 June, 1898	11.50	Newcastle... ...	19 Mar., 1871	11.17
Broger's Creek ...	14 Feb., ,,	20.05	,, ...	9 ,, 1893	11.14
Bulli Mountain ...	19 Mar., 1894	10.45	Nowra	11 July, 1904	11.50
,, ,, ...	13 Feb., 1898	17.14	Parramatta ...	28 May, 1889	11.94
Burwood	28 May, 1889	11.75	,, ...	20 Mar., 1892	11.01
Camden	11 July, 1904	10.90	Port Macquarie ...	9 Nov., 1887	10.76
Camden Haven ...	22 Jan., 1895	12.23	Port Stephens ...	9 Feb., 1889	10.15
Canley Vale ...	28 May, 1889	10.06	Prospect	28 May, ,,	12.37
,, ,, ...	20 Mar., 1892	10.85	Raymond Terrace ...	28 Sep., 1903	10.32
Castle Hill... ...	28 May, 1889	13.49	Richmond ...	28 May, 1889	12.18
Colombo Lyttleton ...	5 Mar., 1893	12.17	Robertson... ...	14 Feb., 1898	10.00
Condong	27 ,, 1887	18.66	,, ...	10 July, 1904	10.50
,, ...	15 Jan., 1890	11.50	Rooty Hill ...	27 May, 1889	11.85
Cookville	1 Apr., 1892	11.31	Rylstone	28 ,, ,,	10.26
Coramba	11 June, 1893	10.83	Seven Oaks ...	22 June, 1898	11.06
Cordeaux River ...	26 Feb., 1873	10.98	Springwood ...	7 Mar., 1894	10.55
,, ,, ...	3 ,, 1890	11.51	Taree	28 Feb., 1892	12.24
,, ,, ...	14 Feb., 1898	22.58	Terara	26 ,, 1873	12.57
,, ,, ...	31 Aug., 1906	10.31	Tomago	9 Mar., 1893	13.76
Cudgen	15 Mar., 1894	10.23	Tongarra	9 July, 1904	11.10
Dapto West ...	14 Feb., 1898	12.05	Tongarra Farm ...	14 Feb., 1898	15.12
Darkes' Forest ...	8 ,, 1895	11.10	Towamba	5 Mar., 1893	20.00
Dunheved	28 May, 1889	12.40	Tweed Heads ...	14 Jan., 1890	10.53
Eden	4 ,, 1875	10.52	,, ,, ...	14 Mar., 1894	11.40
Fernmount ...	2 Feb., 1890	10.36	Trial Bay	9 ,, 1893	11.13
,, ...	2 June, 1903	11.29	Wollongong ...	26 Feb., 1873	11.00
Goorangoola ...	9 Mar., 1893	10.34	,, ...	5 Apr., 1882	10.00
Guy Fawkes ...	2 June, 1903	11.30	Woolgoolga ...	11 June, 1893	10.83
Hercynia	28 May, 1889	11.85	Yellow Rock ...	14 Feb., 1898	11.69
Holy Flat	12 Mar., 1887	12.00	South Head		
,, ,, ...	28 Feb., 1892	12.24	(near Sydney)...	29 Apr., 1841	20.12
Jamberoo	14 ,, 1898	10.92	,, ,, ...	16 Oct., 1844	20.41
Kareela	20 Oct., 1902	11.73			

HEAVY RAINFALLS, QUEENSLAND, UP TO 1896, INCLUSIVE.

Ayr	20 Sep., 1890	14.58	Bowen Park ...	16 Feb., 1893	10.38
,, ...	25 Mar., 1891	10.19	Brisbane	21 Jan., 1887	18.31
,, ...	26 Jan., 1896	10.50	Bromby Park (Bowen)	14 Feb., 1893	13.28
Beenleigh	21 ,, 1887	11.30	,, ,, ...	20 Jan., 1894	11.20
Bloomsbury ...	14 Feb., 1893	17.40	Bulimba (Brisbane)...	16 Feb., 1893	10.40
,, ...	27 Jan., 1896	10.52	Bundaberg ...	31 Jan., 1893	10.15
Bowen	13 Feb., 1893	14.65	Burketown ...	15 ,, 1891	13.58
,, ...	20 Jan., 1894	11.11	Bustard Head ...	18 Feb., 1888	10.14

HEAVY RAINFALLS, QUEENSLAND—Continued.

Name of Town or Locality.	Date.	Amnt.	Name of Town or Locality.	Date.	Amnt.
		ins			ins.
Bustard Head	30 Jan., 1893	11.85	Lytton	13 Mar., 1892	10.60
Caboolture	21 ,, 1887	10.00	,,	16 Feb., 1893	11.74
Cairns	11 Feb., 1889	14.74	Mackay	17 ,, 1888	10.10
,,	21 Apr., ,,	12.40	,,	15 ,, 1893	10.46
,,	5 ,, 1891	14.08	Macnade Mill		
,,	19 Jan., 1892	10.56	(Townsville)	28 Mar., 1891	10.61
Caloundra	21 ,, 1887	10.50	,,	15 ,, 1893	10.50
Cape Grafton	5 Mar., 1896	13.37	,,	18 Jan., 1894	12.56
Cardwell	18 ,, 1887	10.15	,,	17 Apr., ,,	14.26
,,	30 Dec., 1889	12.00	Marlborough	17 Feb., 1888	14.24
,,	2 Jan., 1890	10.06	,,	29 Jan., 1896	10.84
,,	23 Mar., ,,	12.00	Mein	4 Apr., 1895	10.50
Clare	26 Jan., 1896	15.30	Mooloolah	13 Mar., 1892	11.53
Collaroy	30 ,, ,,	14.25	,,	2 Feb., 1893	29.11
Cooran	1 Feb., 1893	13.62	,,	9 June, ,,	11.50
,,	9 June, ,,	10.12	Mount Perry	24 Feb., 1887	10.00
Cooroy	9 ,, ,,	13.60	Mundoolun	21 Jan., ,,	17.95
Cressbrook	16 Feb., ,,	10.65	Musgrave	6 Apr., 1894	13.71
Crohamhurst			Nanango	9 June, 1893	10.00
(Blackall Range)	31 Jan., ,,	10.78	Nerang	15 ,, 1892	12.35
,, ,,	2 Feb., ,,	35.71	Netley (Rockhampton)	29 Jan., 1896	11.77
Crohamhurst	9 June, ,,	13.31	North Pine	21 ,, 1887	11.60
Cryna (Beaudesert)	21 Jan., 1887	14.00	,, ,,	16 Feb., 1893	14.97
Donaldson	27 ,, 1891	11.29	Palmwoods	4 ,, ,,	12.30
Dungeness	16 Mar., 1893	22.17	Pittsworth	11 Mar., 1890	14.68
,,	19 Jan., 1894	11.84	Port Douglas	5 ,, 1887	13.00
,,	17 Apr., ,,	14.00	,, ,,	12 Feb., 1888	10.00
Eddington (Cloncurry)	23 Jan., 1891	10.33	,, ,,	20 Jan., 1892	11.50
Emu Park	31 ,, 1893	10.00	,, ,,	23 Feb., 1894	10.25
Esk	21 ,, 1887	10.70	,, ,,	7 Apr., ,,	10.00
Fassifern	21 ,, ,,	10.20	Ravenswood	24 Mar., 1890	17.00
Geraldton	11 Feb., 1889	17.13	,,	27 Jan., 1896	10.52
,,	31 Dec., ,,	12.45	Redcliffe	21 ,, 1887	14.00
,,	25 Jan., 1892	11.10	,,	16 Feb., 1893	17.35
,,	6 Apr., 1894	16.02	Rockhampton	17 ,, 1888	10.82
,,	3 Mar., 1896	11.42	,,	29 Jan., 1896	10.53
Gladstone	18 Feb., 1888	12.37	Sandgate	21 ,, 1887	10.50
,,	31 Jan., 1893	14.62	,,	16 Feb., 1893	14.03
Glen Broughton	5 Apr., 1894	18.50	St. Helens	16 ,, ,,	11.20
Gold Creek Reservoir	16 Feb., 1893	11.16	St. Helens (Mackay)	24 ,, 1888	12.00
Goodna	21 Jan., 1887	11.00	St. Lawrence	17 ,, ,,	12.10
Goondi Mill (Gerald'n)	20 ,, 1892	11.10	,, ,,	30 Jan., 1896	15.00
,, ,,	6 Apr., 1894	15.69	Tabragalba	21 ,, 1887	10.00
Haughton Valley	26 Jan., 1896	18.10	Tambourine Mountain	17 July, 1889	10.91
Holmwood (Woodford)	2 Feb., 1893	16.19	The Hollow (Mackay)	23 Feb., 1888	15.12
Ingham	18 Jan., 1894	12.60	,, ,,	? Mar., 1891	10.39
,,	7 Apr., ,,	10.10	Tooloombah	29 Jan., 1896	11.70
Inkerman	21 Sep., 1890	12.93	Townsville	24 ,, 1892	19.20
Inneshowen			Woodford	2 Feb., 1893	14.93
(Johnstone River)	30 Dec., 1889	14.01	Woodlands (Yeppoon)	10 ,, 1889	10.00
Inskip Point	13 Mar., 1892	10.65	,, ,,	26 Jan., 1890	10.22
Kamerunga (Cairns)	20 Jan., ,,	13.61	,, ,,	25 Mar., ,,	14.25
,, ,,	23 Feb., 1894	10.10	,, ,,	31 Jan., 1893	23.07
Kamerunga	6 Apr., ,,	14.04	,, ,,	30 ,, 1896	11.91
,,	5 ,, 1895	12.31	,, ,,	9 Feb., ,,	13.97
,,	5 Mar., 1896	11.81	Yandina	1 ,, 1893	20.08
Lake Nash	10 Jan., 1895	10.02	,,	9 June, ,,	12.70
Landsborough	2 Feb., 1893	25.15	Yeppoon	31 Jan., ,,	20.05
,,	9 June, ,,	12.80	,,	30 ,, 1896	11.02
Lytton	21 Jan., 1887	12.85			

HEAVY RAINFALLS, WESTERN AUSTRALIA, UP TO 1907, INCLUSIVE.

Name of Town or Locality.	Date	Amnt.	Name of Town or Locality.	Date.	Amnt.
		ins.			ins.
Balla Balla ...	20 Mar., 1899	6.00	Port Hedland ...	7 Feb., 1901	3.56
" " ...	21 " 1899	14.40	"	8 " "	9.55
Boodaril	3 Jan., 1894	10.03	Roebourne... ...	3 Apr., 1898	11.44
"	4 " "	5.22	"	6 Mar., 1900	10.32
"	21 Mar., 1899	14.53	Tambrey	6 " "	11.00
"	6 Feb., 1901	1.91	"	3 " 1903	10.46
"	7 " "	9.16	Thangoo	17-19 Feb.'96	24.18
Bamboo Creek ...	22 Mar., 1899	10.10	"	28 Dec., 1898	11.15
Carlton	11 Jan., 1903	10.64	Whim Creek ...	2 Apr., 1898	7.08
Cossack	3 Apr., 1898	12.82	"	3 " "	29.41
"	15 " 1900	6.89	"	20 Mar., 1899	8.89
"	16 " "	13.23	"	21 " "	18.17
Croydon	3 Mar., 1903	12.00	"	6 " 1900	10.03
Cocos Island ...	29 Nov., "	14.38	"	3 " 1903	10.44
Derby	29 Dec., 1898	13.09	Wyndham... ...	27 Jan., 1890	11.60
"	30 " "	7.14	"	11 " 1903	9.98
Kerdiadary ...	7 Feb., 1901	12.00	"	12 " "	6.64
Millstream ...	5 Mar., 1900	10.00	"	13 " "	4.20
Obagama	16 Feb., 1896	3.95	Yeeda	28 Dec., 1898	8.42
"	17 " "	6.30	"	29 " "	6.88
"	18 " "	7.22	"	30 " "	6.12
Point Torment ...	17 Dec., 1906	11.86			

HEAVY RAINFALLS, SOUTH AUSTRALIA, UP TO 1907, INCLUSIVE.

Borroloola... ...	14 Mar., 1899	14.00	Pine Creek ...	8 Jan., 1897	10.35
Lake Nash ...	21 " 1901	10.25	Port Darwin ...	7 " "	11.67

16. **Snowfall.**—Light snow has been known to fall even as far north, occasionally, as latitude 31° S., and from the western to the eastern shores of the continent. During exceptional seasons it has fallen simultaneously over two-thirds of the State of New South Wales, and has extended at times along the whole of the Great Dividing Range, from its southern extremity in Victoria as far north as Toowoomba in Queensland. During the winter snow covers the ground to a great extent on the Australian Alps for several months, where also the temperature falls below zero Fahrenheit during the night, and in the ravines around Kosciusko and similar localities the snow never entirely disappears.

The antarctic "V"-shaped disturbances are always associated with our most pronounced and extensive snowfalls. The depressions on such occasions are very steep in the vertical area, and the apexes are unusually sharp-pointed and protrude into very low latitudes, sometimes even to the tropics.

17. **Hail.**—Hail falls throughout Australia most frequently along the southern shores of the continent, and in the summer months. The size of the hailstones generally increases with distance from the coast, a fact which lends strong support to the theory that hail is brought about by ascending currents. Rarely does a summer pass without some station experiencing a fall of stones exceeding in size an ordinary hen-egg, and many riddled sheets of light-gauged galvanised iron bear evidence as to the weight and penetrating power of the stones.

Hail storms occur most frequently in Australia when the barometric readings indicate a flat and unstable condition of pressure. They are invariably associated with tornadoes or tornadic tendencies, and on the east coast the clouds from which the stones fall are generally of a remarkable sepia-coloured tint.

18. **Barometric Pressures.**—The mean annual barometric pressure in Australia varies from 29.88 inches on the north coast to 30.06 inches over the central and southern parts of the continent. In January the mean pressure ranges from 29.76 inches in the northern and central areas to 29.94 and 29.95 inches in the southern. The July mean pressure ranges from 29.97 inches at Port Darwin to 30.18 at Alice Springs. Barometer readings, corrected to mean sea-level, have, under anticyclonic conditions in the interior of the continent, ranged from 30.81 inches to as low as 28.44 inches. This lowest record was registered at Townsville during a hurricane on the 9th March, 1903. The mean annual fluctuations of barometric pressure for the capitals of Australia are shewn on page 137.

19. **Wind.**—(i.) *Trade Winds.* The two distinctive wind currents in Australia are, as previously stated, the south-east and westerly trade winds. As the belt of the earth's atmosphere in which they blow apparently follows the sun's ecliptic path north and south of the equator, so the area of the continent affected by these winds varies at different seasons of the year. During the summer months the anticyclonic belt travels in very high latitudes, thereby bringing the south-east trade winds as far south as 30° south latitude. The westerly trade winds are forced a considerable distance to the south of Australia, and are very rarely in evidence in the hot months. When the sun passes to the north of the equator, the south-east trade winds follow it, and only operate to the north of the tropics for the greater part of the winter. The westerly winds, by the same force, are brought into lower latitudes during the same period of the year. They sweep across the southern areas of the continent from the Leeuwin to Cape Howe, and during some seasons are remarkably persistent and strong. They occasionally penetrate to almost tropical latitudes, and though usually cold and dusty, are of the greatest service to the country, for being rain-bearing winds, moisture is by their agency precipitated over vast areas in the south of the continent.

(ii.) *Land and Sea Breezes.* The prevailing winds second in order of importance are the land and sea breezes. These generally blow at right angles to the coast line in their early stages, but are deflected to the north and south in the middle and later periods of the blows.

On the east coast the sea breezes which come in from the north-east, when in full force, frequently reach the velocity of a gale during the afternoon in the summer months, the maximum hourly velocity, ordinarily attained about 3 p.m., not unfrequently attaining a rate of 35 to 40 miles per hour. This wind, although strong, is usually shallow in depth, and does not ordinarily penetrate more than 9 or 12 miles inland.

The land breezes on the east coast blow out from a south-westerly direction during the night.

On the western shores of the continent the directions are reversed. The sea breezes come in from the south-west, and the land breezes blow out from the north-east.

(iii.) *Inland Winds.* Inland, the direction of the prevailing winds is largely regulated by the seasonal changes of pressure, so disposed as to cause the winds to radiate spirally outwards from the centre of the continent during the winter months, and to circulate spirally from the seaboard to the centre of Australia during the summer months.

(iv.) *Prevailing Direction at the State Capitals.* In *Perth*, southerly is the prevailing direction for November to February inclusive, and north-north-easterly for the mid-winter months.

In *Adelaide* the summer winds are from the south-west and south, and in the winter from north-east to north.

In *Brisbane*, south-east winds are in evidence all the year round, but more especially during the months January, February, March and April.

In *Sydney* from May to September the prevailing direction is westerly, and for the remaining seven months north-easterly.

Melbourne winter winds are from north-west to north-east, and those of the summer from south-west to south-east.

At *Hobart* the prevailing direction for the year is from north-west.

Over the greater part of Australia January is the most windy month, *i.e.*, is the month when the winds are strongest on the average, though the most violent wind storms occur at other times during the year, the time varying with the latitude.

20. **Cyclones and Storms.**—(i.) *General.* The "elements" in Australia are ordinarily peaceful, and although severe cyclones have visited various parts, more especially coastal areas, such visitations are rare, and may be properly described as erratic.

During the winter months the southern shores of the continent are subject to cyclonic storms, evolved from the V-shaped depressions of the southern low-pressure belt. They are felt most severely over the south-western parts of Western Australia, to the south-east of South Australia, in Bass Straits, including the coast-line of Victoria, and on the west coast of Tasmania. Apparently the more violent wind pressures from these cyclones are experienced in their northern half, that is, in that part of them which has a north-westerly to a south-westerly circulation.

Occasionally the north-east coast of Queensland is visited by hurricanes from the north-east tropics. During the first three months of the year these hurricanes appear to have their origin in the neighbourhood of the South Pacific Islands, their path being a parabolic curve of south-westerly direction. Only a small percentage, however, reach Australia, the majority recurving in their path before reaching New Caledonia.

Anemometrical records for these storms do not exist, but the fact that towns visited by them have been greatly damaged indicates that the velocity must be very great. Fortunately the area covered by these storms is very small when compared with the southern cyclones, and the region affected during an individual visitation is very limited. The heaviest blows are experienced to the west of the vortex with south-east to south-west winds.

(ii.) *Severe Cyclones.* Very severe cyclones, popularly known as "Willy Willies," are peculiar to the north-west coast of Western Australia from the months of December to March, inclusive. They apparently originate in the ocean, in the vicinity of the Cambridge Gulf, and travel in a south-westerly direction with continually increasing force, displaying their greatest energy near Cossack and Onslow, between latitudes 20° and 22° South. The winds in these storms, like those from the north-east tropics, are very violent and destructive, causing great havoc amongst the pearl-fishers. The greatest velocities are usually to be found in the south-eastern quadrant of the cyclones, with north-east to east winds. After leaving the north-west coast, these storms either travel southwards, following the coast-line, or cross the continent to the Great Australian Bight. When they take the latter course their track is marked by torrential rains, as much as 29.41 inches, for example, being recorded at Whim Creek from one such occurrence. Falls of 10 inches and over have frequently been recorded in the interior of Western Australia from similar storms.

Cyclones occasionally develop from incipient monsoonal low-pressures in the interior of the continent. Their formation is apparently materially assisted by the advancing high-pressures to the west of them, for they seldom or never appear without this accompaniment. The velocity and duration of the resultant gales, too, has a distinct relation to the magnitude of pressure in the anti-cyclones. Evidence of excess of high pressures on such occasions indicates severe gales in the cyclones, and in the case of moderate pressures, moderate gales.

These cyclones do not attain their severest phases until they reach the seaboard. The most violent winds occur in the south-western quadrant, with south-west to south-east winds. The area affected on the coast-line is not usually very great. During the visitation of one of these storms, about 500 miles in diameter, in July, 1903, a strip of land, only 80 miles in extent, was affected. But so severe was the gale within this region that steamers of from 8000 to 10,000 tons, leaving Port Jackson, were buffeted and tossed about like corks by the turbulent sea. Notwithstanding this, vessels 200 miles to the east lay becalmed and had no indication of the violent atmospheric upheaval relatively so near.

Though storms of this type may occur at any time of the year, they are more frequent during the months of August and September. The velocity of the wind has on one occasion reached the rate of 120 miles per hour.

(iii.) *Southerly Bursters.* The "Southerly Burster" is a characteristic feature of the eastern part of Australia. It is a cool, or cold, wind peculiar to the coastal districts of New South Wales, south of latitude 30°. In a modified form, however, it also appears in the interior of that State, in Victoria, and the western districts of Queensland.

The "Southerly Bursters" invariably follow periods of hot weather, and are a great relief to the population settled over the favoured areas. They occur in all months from August to May inclusive, but most frequently in November. The preceding winds in the early and late summer months are from a north-westerly, and in the midsummer months from a north-easterly direction. A rise in the barometer always takes place before their advent, but no relation has been established between the time this rise begins and the moment of the arrival of the wind itself, neither is there any apparent connection between the velocity of the wind and the rate of gradient of the barometric rise, notwithstanding that records of nearly fifteen hundred "Bursters," extending over a period of forty years, have been analysed with a view of ascertaining if such a connection could be established. All that can be said is that, should the rise be sharp and rapid, the life of the blow will be short, while a slow and gradual one indicates a long and steady blow from the south, after the initial "Burster" has passed. "Southerly Bursters" are usually first noted on the extreme south coast, and travel northward at a rate of 20 miles an hour. The rate of translation has ordinarily no definite relation to the velocity attained by the wind itself.

"Bursters" frequently occur simultaneously at several places along the seaboard, and occasionally they have been known to progress down the coast from north to south. While they may arrive at any time during the day or night, the interval between sundown and midnight is that in which they ordinarily occur.

This type of storm is usually associated with "V"-shaped depressions, but occasionally a condition of relatively high barometric pressures in Victoria will induce their occurrence. It is most frequent during seasons of sporadic rains, and very rare during good years in the interior. In the summer of 1890, the year of the great Darling River flood, only sixteen visitations occurred, and even these were of a very mild character. The series of good years in the interior of Australia, since 1903, has been remarkable for the small annual number of "southerly bursters."

The greatest number ever experienced in a single summer was sixty-two, the average being thirty-two.

In the months of December and January they are usually short lived, and two may occur within the twenty-four hours. In the early and late summer months the intervening periods of warm weather are longer, and the winds are longer sustained, the energy being supplied from the more pronounced high pressures prevailing at these seasons of the year. The velocity varies from a rate of a few miles an hour to over 80 miles per hour, the maximum puffs occurring about an hour after the arrival of the burster. During recent years there has been a falling-off both in their number and strength, the reason for which is not yet understood, but it is suspected that the gradual extension of the agricultural and pastoral industries to the interior of the country may be one of the causes of the change.

Winds of a like character, and possibly derived from similar atmospheric actions and conditions, are—

In Europe—"The Bora," a sharp, cold north-east wind, which blows from the Croatian and Illyrian Mountains along the coast of Dalmatia from Trieste southward;

and the "Mistral," a violent northerly wind which blows from France to the Gulf of Lyons.

In North America, the "Northers" of Texas have similar characteristics, and in South America "The Pampero," a cold and strong southerly wind which blows over the Pampas of Argentina, is almost identical with the "Southerly Bursters." The "Tehuantepec" winds that blow on the Pacific side of Central America are also very similar.

All parts of Australia are subject during the summer months to hot, desiccating winds, of two kinds. The most common and general class are associated with low-pressure isobars. The more rare and local hot winds are caused by the heating of descending air on the lee-side of mountains. In Victoria the former class are known as "Brick Fielders," a name originally applied to the "Southerly Bursters" in Sydney, because of the dust they raised from the brickfields to the south of the city. When the goldfields were discovered in Victoria the miners hailing from Sydney gave the name to the dusty winds from the opposite quarter.

The hot winds on the south-eastern littoral are analogous to the "Chinook" winds which blow at the eastern foot of the Rocky Mountains; to the "Fœhn" winds of the Alpine Valleys; and to the "North-Westers" of the Canterbury Plains in the Middle Island of New Zealand.

21. **Influences affecting Australian Climate.**—Australian history does not cover a sufficient period, nor is the country sufficiently occupied, to ascertain whether or not the advance of settlement has materially affected the climate as a whole. Local changes therein, however, have taken place, a fact which suggests that settlement and the treatment of the land have a distinct effect on local conditions. For example, the mean temperature of Sydney shews a rise of two-tenths of a degree during the last twenty years, a change probably brought about by the great growth of residential and manufacturing buildings within the city and in the surrounding suburbs during that period. Again, low-lying lands on the north coast of New South Wales, that originally were seldom subject to frosts, have with the denudation of the surrounding hills from forests experienced annual visitations, the probable explanation being that, through the absence of trees, the cold air of the high lands now flows, unchecked and untempered, down the sides of the hills to the valleys and lower lands.

It is pointed out by Abercromby,[1] as shewing the influence of irrigation on climate, that "Before the Suez Canal was made, the desert through which it is cut was said to be rainless; now since the Bitter Lakes have been filled up with water, rain falls on an average eight days in the year at Ismailia." And in the United States, General A. W. Greely[2] says, concerning "Heat Waves," "It seems possible that the frequency and intensity of such visitations have diminished on the Pacific coast, since Tennant's record of hot days (classing as such those on which the temperature rose to 80° or above, at San Francisco) indicates that their annual number has very materially diminished since 1859. For seven years prior to 1859 such days averaged thirteen yearly, and since that time, up to 1871, the average yearly number is but four. The immense quantity of land placed under irrigation and the vast increase in vegetation are obvious reasons why there should be some diminution in this respect."

(i.) *Influences of Forests on Climate.* As already indicated, forests doubtless exercise a great influence on local climate, and hence, to the extent that forestal undertakings will allow, the weather can be controlled by human agency. The direct action of forests is an equalising one; thus, especially in equatorial regions and during the warmest portion of the year, they considerably reduce the mean temperature of the air. They also reduce the diurnal extremes of their shade temperatures, by altering the extent of radiating surface, by evaporation, and by checking the movement of air. While decreasing

1. "Seas and Skies," Hon. Ralph Abercromby. 8vo, London, 1888, p. 30.
2. "American Weather." 8vo, London, 1888, p. 253.

evaporation from the ground, they increase the relative humidity. Vegetation greatly diminishes the rate of flow-off of rain, and the washing away of surface soil. Thus when a region is protected by trees, steadier water supply is ensured, and the rainfall is better conserved. In regions of snowfall the supply of water to rivers is similarly regulated, and without this and the sheltering influence of ravines and "gullies" watercourses supplied mainly by melting snow would be subject to alternate periods of flooding and dryness. This is borne out in the inland rivers. Thus the River Murray, which has never been known to run dry, derives its steadiness of flow mainly through the causes above indicated.

(ii.) *Direct Influences of Forest on Rainfall.* Whether forests have a direct influence on rainfall is a debatable question, some authorities alleging that precipitation is undoubtedly induced by forests, while others contend the opposite. According to Dr. Hann, observations have been made in India and Germany which support the idea that the destruction of trees has had a most deteriorating effect upon the climate.[1] In the Cordilleras clouds with rain falling from them can be seen hanging over forests, while over contiguous lands covered with shrubs or used for agriculture the sky is blue and the sun is shining.

In America the influence of forests on the rainfall is still debated, but in Europe authorities contend that forests encourage frequent rainfalls. Hann states that a surface which keeps the air moist and cool, and from which there is as great an evaporation as takes place from extended forests, must have a tendency to increase the amount and frequency of precipitation, as contrasted with an open country which is dry, but over which conditions are otherwise similar.

Obviously the settlement of this very important question is difficult. Observations would have to be taken, with different treatments of the land, over very extended periods. Sufficient evidence exists, however, to establish that, even if the rainfall has not increased, the beneficial effect of forest lands in tempering the effects of the climate is more than sufficient to disclose the importance of their protection and extension. Curtis, in a paper read before the Meteorological Congress in 1893, sets forth important evidence of the ill-effects on orchard and wheat country of the felling of trees for the timber trade.

In Michigan, where half a century ago peach trees flourished and were rarely injured by cold, the crops have now nearly disappeared, owing to the removal by timbermen of the shelter afforded by the forests. In Northern Kansas, too, from the same cause, the growing of peaches has been largely abandoned. Many of the South Californian citrus fruit-growers protect their orchards from the destructive effects of wind by the judicious planting of eucalyptus and other trees.

It is the rapid rate of evaporation (says Dr. Fernow), induced by both hot and cold winds, which injures crops and makes life uncomfortable on the plains. Whether the forest aids in increasing precipitation there may be doubt, but nobody can say that it does not check the winds and the rapid evaporation due to them.

Trees as wind-breaks have been successfully planted in central parts of the United States, and there is no reason why similar experiments should not be successful in many parts of our treeless interior. The belts should be planted at right angles to the direction of the prevailing parching winds, and if not more than half a mile apart will afford shelter to the enclosed areas.[2]

22. **Comparison of Rainfalls and Temperatures.**—For the purpose of comparison the following lists of rainfalls and temperatures are given for various important cities throughout the world, for some of the places mentioned as possible sites for a federal capital, and for the capitals of the Australian States :—

1. "Climatology," p. 194.

2. See A. Woeikof, Petermann's Mittheilungen, 1885; and W. M. Fulton and A. N. Salisbury, "Convention of U.S.A. Weather Bureau Officials, 1898."

COMPARISON OF RAINFALLS AND TEMPERATURES

OF CITIES OF THE WORLD WITH THOSE OF AUSTRALIA,

Place.	Height above M.S.L.	Annual Rainfall.			Temperature.					
		Average.	Highest.	Lowest.	Mean Summer.	Mean Winter.	Highest on Record.	Lowest on Record.	Average Hottest Month.	Average Coldest Month.
	Ft.	Ins.	Ins.	Ins.	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.
Amsterdam ...	...	26.40	...	...	62.9	37.1	93.9	5.8	63.6	35.0
Athens ...	...	...	...	...	...	...	106.0	...	...	...
Berlin ...	161	22.80	27.18	17.97	64.6	32.4	97.5	— 9.6	65.8	30.6
Berne ...	1,880	46.00	...	...	...	...	97.2	—22.0	63.0	27.0
Bombay ...	37	75.00	...	...	83.0	75.0	100.0	53.0	83.0	74.0
Brussels ...	177	28.60	47.00	20.00	63.2	37.2	...	...	65.0	35.6
Budapest...	502	21.50	...	...	...	...	...	...	71.7	31.0
Buenos Ayres ...	72	35.20	78.74	22.76	75.4	51.4	103.1	28.4	75.0	50.0
Calcutta ...	21	65.60	...	...	84.7	66.7	108.0	44.0	85.0	65.0
Capetown ...	40	25.50	36.72	17.71	68.1	54.7	102.0	34.0	68.8	53.9
Chicago ...	595	33.40	45.80	24.40	70.0	26.0	103.0	23.0	72.0	24.0
Christiania ...	82	21.10	...	...	...	...	91.2	...	63.0	23.5
Colombo...	40	87.36	...	...	81.0	79.5	95.8	65.2	82.5	79.0
Constantinople ...	...	28.75	42.74	14.78	74.0	43.5	103.6	13.0	75.7	42.0
Copenhagen ...	46	21.80	27.87	21.58	60.5	31.9	90.5	— 9.7	61.9	31.4
Dublin ...	155	29.20	35.57	20.47	58.9	42.0	87.0	13.0	63.5	32.8
Edinburgh ...	441	25.00	32.89	16.50	59.0	38.4	88.0	0.0	58.0	37.0
Genoa ...	177	45.00	...	...	...	...	...	...	...	...
Hong Kong ...	110	84.88	100.0	57.03	80.9	59.1	92.9	40.6	80.9	55.3
Johannesburg ...	5,925	30.64	43.39	21.66	65.0	51.5	94.0	23.3	66.8	40.6
Lisbon ...	312	31.00	102.0	27.50	69.6	51.3	94.1	32.5	...	...
London ...	154	24.36	34.08	16.93	61.2	39.3	97.1	4.0	62.7	38.6
Madras ...	22	49.00	...	...	87.3	76.7	112.0	57.0	89.3	76.1
Madrid ...	2,149	17.99	27.48	11.22	73.0	41.2	107.1	10.5	75.7	39.7
Marseilles ...	246	21.73	43.05	12.05	70.3	46.0	100.4	11.5	83.0	56.3
Moscow ...	469	21.30	...	...	63.5	49.0	...	...	68.0	12.0
Naples ...	187	32.60	...	...	76.1	49.3	104.0	23.0	77.2	48.2
New York ...	175	30.70	37.60	24.30	67.0	19.0	97.0	—28.0	69.0	16.0
Ottawa ...	294	33.19	38.05	25.25	66.7	15.0	98.3	—31.6	68.7	12.6
Paris ...	104	19.68	26.18	15.28	63.0	38.4	101.1	—14.0	66 0	36.3
Pekin ...	...	24.40	...	...	...	...	...	...	79.2	23.6
Quebec ...	293	45 to 50	...	...	63.0	14.0	...	...	66.0	9.4
Rome ...	164	27.84	36.29	19.84	74.0	46.6	100.4	19.6	76.5	45.7
San Francisco ...	28	22.50	38.70	9.30	59.0	51.0	100.0	29.0	61.0	50.0
Shanghai ...	...	...	...	...	79.4	41.1	102.0	12.2	82.7	37.7
Singapore ...	...	92.70	123.24	65.56	...	...	93.0	...	...	...
Stockholm ...	144	15.70	...	...	...	...	...	...	63.0	24.5
St. Petersburg ...	16	20.86	25.11	15.74	61.0	19.0	87.4	—30.3	64.0	17.1
Tokyo ...	69	58.00	...	...	74.1	38.6	98.0	15.0	77.4	36.6
Vienna ...	666	25.82	37.60	20.04	65.3	30.9	101.7	—13.9	67.5	28.6
Vladivostock ...	100	12.60	...	...	...	...	...	...	69.5	5.0
Washington ...	73	43.10	61.30	30.60	75.0	35.0	104.0	—15.0	77.0	33.0
PLACES WHICH HAVE BEEN REFERRED TO AS POSSIBLE SITES FOR THE FEDERAL CAPITAL.					*	†				
Armidale... ...	3,333	31.79	59.34	16.61	66.0	44.1	105.2	13.9	69.1	42.1
Bombala... ...	3,000	22.92	38.18	11.88	61.0	42.8	104.1	15.5	65.2	41.3
Canberra (District) ...	2,000 to 2,900	23.00	50.69	16.56	68.0	44.7	109.0	16.0	72.0	42.0
Dalgety	2,650	17.82	23.20	13.53	64.2	41.8	104.0	11.0	67.0	40.0
Lyndhurst ...	2,204	26.29	31.74	19.05	...	...	...	...	...	...
Tumut	900	31.96	47.87	16.83	...	...	...	...	...	...
THE STATE CAPITALS.					*	†				
Perth	197	33.18	46.73	20.48	71.0	56.0	107.9	36.4	73.8	55.2
Adelaide... ...	140	20.33	30.87	13.43	71.3	52.9	116.3	32.2	74.0	51.5
Brisbane... ...	137	43.44	88.23	16.17	75.5	59.5	108.9	36.1	77.3	58.0
Sydney	144	48.54	82.81	21.48	69.7	53.8	108.5	35.9	71.5	52.3
Melbourne ...	91	25.57	44.25	15.61	64.9	50.0	111.2	27.0	67.3	48.5
Hobart	160	23.53	40.67	13.43	60.1	47.0	105.2	27.7	62.0	45.7

* Mean summer temperature derived from the average for November, December, January, February and March. † Mean winter temperature derived from the average for June, July, and August.

23. **Climatological Tables.**—The means, averages, extremes, totals, etc., for a number of climatological elements have been determined from long series of observations at the Australian capitals. These are given in the following tables:—

CLIMATOLOGICAL DATA FOR PERTH, W.A.

LAT. 31° 57′ S., LONG. 115° 51′ E. HEIGHT ABOVE M.S.L. 197 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m. & 3 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	11	10	10	10	10	9	11	11	11
January	29.950	797 27/98	0.73	11,667	S	10 36	1.0	2.4	15.0
February	29.961	606 10/05	0.68	10,281	S S E	8 65	1.2	2.7	12.6
March	30.022	601 17/99	0.56	10,231	S S E	·7.61	0.9	3.1	12.8
April	30.099	955 25/1900	0.44	8,811	S S E	4.76	0.8	4.4	7.4
May	30.124	698 5/05	0.36	8,219	E N E	2.64	2.3	5.2	5.3
June	30.080	836 29/1900	0.40	8,298	N N E	1.59	1.7	6.0	2.9
July	30.130	949 11/99	0.41	8,626	N	1.61	2.5	5.4	6.2
August	30.132	966 15/03	0.45	9,137	S W	2.32	1.5	5.2	5.6
September	30.093	864 11/05	0.48	9,156	S W	3.23	1.8	5.6	4.3
October	30.052	686 15/98	0.60	10,508	S S W	5.29	1.3	5.4	4.9
November	30.038	777 18/97	0.65	10,581	S	7.79	0.9	3.8	8.9
December	29.968	672 31/98	0.72	11,483	S	9.95	1.5	3.0	12.4
Year Totals ...	—	—	—	—	—	65.81	17.4	—	98.3
Year Averages ...	30.054	—	0.53	9,750	S	—	—	4.4	—
Year Extremes ...	—	966 15/8/03	—	—	—	—	—	—	—

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.	Extreme Shade Temperature. Lowest.	Greatest Range.	Extreme Temperature. Highest in Sun.	Extreme Temperature. Lowest on Grass.	Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	11	11	11	11	11	11	10	10	—
January	84.2	63.1	73.6	107.0 16/97	50.6 25/01	56.4	171.1 4/04	42.4 25/02	—
February	84.5	63.1	73.8	106.8 6/98	47.7 1/02	59.1	169.0 4/99	41.2 1/02	—
March	81.8	60.7	71.2	104.3 6, 7/06	45.8 8/03	58.5	161.6 1/99	36.7 8/03	—
April	76.0	56.6	66.3	98.0 5/06	42.4 2/01	55.6	152.0 11/01	35.0 2/03	—
May	68.9	52.6	60.8	90.4 2/07	39.9 *	50.5	138.8 15/02	31.9 18/99	—
June	63.8	49.4	56.6	73.5 6/07	36.9 14/98	36.6	131.0 5/04	30.2 14/98	—
July	62.7	47.6	55.2	73.8 24/99	36.4 19/06	37.4	131.0 31/98	30.7 6/99	—
August	64.0	48.2	56.1	80.4 30/02	37.5 11/97	42.9	134.1 †	30.6 13/05	—
September	65.6	50.1	57.4	86.4 28/1900	39.0 18/00	47.4	144.8 19/02	33.2 15/99	—
October	69.1	53 1	61.1	93.4 17/06	41.2 10/03	52.2	152.6 30/01	34.6 6/98	—
November	74.8	56.3	65.6	100.9 27/01	42.0 1/04	58.9	161.5 17/03	36.9 1/04	—
December	80.5	60.5	70.5	107.9 20/04	49.2 1/97	58.7	168.3 20/04	42.0 5/02	—
Year Averages ...	73.0	55.1	64.0	—	—	—	—	—	—
Year Extremes ...	—	—	—	107.9 20/12/04	36.4 19/7/06	59.1	171.1 4/1/04	30.2 14/6/98	-

* 17, 18/1899. † 29/1898; 18/1902.

HUMIDITY, RAINFALL, AND DEW.

Month.	Humidity. Mean 9 a.m.	Humidity. Highest Mean.	Humidity. Lowest Mean.	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.	Rainfall. Least Monthly.	Rainfall. Greatest in One Day.	Dew. Mean Amount of Dew.	Dew. Mean No. days Dew
No. of yrs. over which observation extends	11	11	11	32	32	11	11	11	—	11
January	52	56	45	0.34	2	1.24 1900	nil 1897	0.71	—	1.6
February	53	63	48	0.34	2	0.42 1906	nil 1903	0.20	—	1.6
March	54	59	48	0.77	4	1.59 1901	0.08 1902	1.37	—	2.9
April	63	70	54	1.70	7	3.26 1899	0.22 1902	2.62	—	7.4
May	73	81	63	4.92	14	8.71 1905	0.98 1903	2.08	—	10.5
June	79	83	74	6.56	16	11.19 1900	3.66 1902	2.10	—	10.4
July	79	81	74	6.19	16	10.90 1902	4.39 1897	2.29	—	11.5
August	75	79	68	5.62	17	9.25 1903	0.46 1902	2.79	—	9.5
September	70	76	64	3.30	14	7.72 1903	1.93 1899	1.26	—	6.7
October	62	67	56	2.08	11	4.18 1899	0.86 1897	1.26	—	3.6
November	55	60	52	0.77	5	1.30 1903	0.11 1902	1.11	—	3.3
December	52	56	49	0.59	4	0.77 1905	0.04 1906	0.58	—	2.0
Year Totals ...	—	—	—	33.18	112	—	—	—	—	71.0
Year Averages ...	63	—	—	—	—	—	—	—	—	—
Year Extremes ...	—	83	45	—	—	11.19 6/1900	nil 1/97, 2/03	2.79 7/8/1903	—	—

— Signifies no record kept.

CLIMATOLOGICAL DATA FOR ADELAIDE, S.A.

LAT. 34° 56′ S., LONG. 138° 35′ E. HEIGHT ABOVE M.S.L. 140 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m. & 3 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	51	30	30	30	30	38	36	40	26
January	29.939	758 19/99	0.37	8,312	S W x S	8.95	2.3	3.5	7.3
February	29.979	691 22/96	0.32	6,990	S W x S	7.39	2.1	3.4	7.3
March	30.069	592 12/85	0.26	6,952	S W to S E	5.89	2.2	3.9	6.7
April	30.143	773 10/96	0.24	6,420	S W & S †	3.42	1.6	5.0	3.7
May	30.152	760 9/80	0.21	6,271	N E to N	2.04	1.8	5.7	1.7
June	30.124	750 12/78	0.27	6,827	N E to N	1.25	2.2	6.2	1.3
July	30.164	674 25/82	0.26	6,955	N E to N	1.32	1.5	5.8	1.3
August	30.126	773 31/97	0.30	7,397	N E to N ‡	1.88	2.2	5.7	2.0
September	30.067	720 2/87	0.33	7,537	N E & S W ‖	2.88	2.4	5.2	2.5
October	30.020	768 28/98	0.37	8,305	S W & N E ‖	4.81	3.6	4.9	3.6
November	30.001	677 2/04	0.36	7,937	W S W to S	6.61	3.8	4.5	5.4
December	29.948	675 12/91	0.37	8,268	W S W to S	8.48	2.9	3.8	7.0
Year Totals	—	—	—	—	—	54.92	28.6	—	49.8
Year Averages	30.061	—	0.30	7,348	S W	—	—	4.8	—
Year Extremes	—	773 *	—	—	—	—	—	—	—

* 10/4/96; 31/8/97. † With tendency N E. ‡ With tendency S W. ‖ Equal.

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.	Extreme Shade Temperature. Lowest.	Greatest Range.	Extreme Temperature. Highest in Sun.	Extreme Temperature. Lowest on Grass.	Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	51	51	51	51	51	51	30	47	34
January	86.5	61.6	74.0	116.3 26/58	45.1 21/84	71.2	180.0 18/82	36.5 14/79	70.8
February	86.1	62.0	74.0	113.6 12/99	46.4 13/05	67.2	170.5 10/00	36.7 24/78	70.8
March	81.0	59.0	70.0	108.0 12/61	44.8 /57	63.2	174.0 17/83	33.8 27/80	68.2
April	73.4	54.7	64.1	98.0 10/66	39.6 15/59	58.4	155.0 1/83	30.5 14/79	64.0
May	65.4	50.0	57.7	88.3 5/66	36.9 *	51.4	148.2 12/79	25.9 10/91	59.0
June	60.2	46.7	53.5	76.0 23/65	32.5 27/76	43.5	138.8 18/79	24.5 20/79	54.7
July	58.7	44.4	51.5	74.0 11/06	32.2 11/03	41.8	134.5 26/90	25.0 17/90	52.2
August	61.9	45.7	53.8	82.0 25/62	32.3 17/59	49.7	140.0 31/92	23.5 7/88	53.3
September	66.3	47.8	57.1	90.7 23/82	32.7 4/58	58.0	160.5 23/82	28.0 6/78	56.5
October	72.6	51.4	62.0	100.5 30/59	36.0 /57	64.5	158.8 19/82	28.5 7/96	60.7
November	78.8	55.3	67.1	113.5 21/65	40.9 6/67	72.6	166.9 20/78	31.8 10/77	65.2
December	83.7	59.0	71.3	114.2 14/76	43.0 †	71.2	175.7 7/99	32.5 4/84	68.7
Year Averages	72.9	53.1	63.0	—	—	—	—	—	62.0
Year Extremes	—	—	—	116.3 26/1/58	32.2 11/7/03	84.1	180.0 18/1/82	23.5 7/8/88	—

* 26/95; 24/1904. † 16/1861; 4/1906.

HUMIDITY, RAINFALL, AND DEW.

Month.	Humidity. Mean 9 a.m.	Humidity. Highest Mean.	Humidity. Lowest Mean.	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.	Rainfall. Least Monthly.	Rainfall. Greatest in One Day.	Dew. Mean Amount of Dew.	Dew. Mean No. days Dew.
No. of yrs. over which observation extends	40	40	40	51	51	51	51	51	—	36
January	42	59	33	0.84	5	3.28 1870	nil 1878,1906	2.30	—	3
February	44	56	37	0.59	4	3.10 1858	nil 1860	1.81	—	4
March	49	58	40	1.07	6	4.60 1878	nil 1859	3.50	—	10
April	59	72	44	1.86	10	5.65 1889	0.086 1888	3.15	—	13
May	70	76	58	2.74	14	7.75 1875	0.196 1891	2.47	—	15
June	78	84	70	2.98	17	6.02 1887	0.423 1886	1.45	—	15
July	78	83	72	2.57	17	5.38 1865	0.365 1899	1.75	—	16
August	72	77	65	2.33	16	4.48 1864	0.675 1860	1.44	—	16
September	63	72	54	1.73	14	3.67 1877	0.448 1896	1.42	—	15
October	54	67	44	1.75	12	3.83 1870	0.306 1888	1.46	—	11
November	47	57	38	1.03	7	2.57 1903	0.039 1885	1.88	—	6
December	43	50	33	0.84	6	3.98 1861	nil 1904	1.32	—	3
Year Totals	—	—	—	20.33	128	—	—	—	—	127
Year Averages	56	—	—	—	—	—	—	—	—	—
Year Extremes	—	84	33	—	—	7.75 5/1875	nil *	3.50	—	—

— Signifies no record kept. * Jan., Feb., Mar. and Dec., various years.

CLIMATOLOGICAL DATA FOR BRISBANE, QUEENSLAND.

LAT. 27° 28′ S., LONG. 153° 2′ E. HEIGHT ABOVE M.S.L. 137 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m. & 3 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	21	—	—	—	21	6	—	21	—
January	29.911	—	—	—	S E, E, N E	9.37	—	5.8	—
February	29.944	—	—	—	S, S E, E	7.93	—	5.9	—
March	30.011	—	—	—	S to E	7.27	—	5.6	—
April	30.099	—	—	—	S to S E	6.68	—	4.8	—
May	30.149	—	—	—	S'ly & W'ly	5.41	—	4.7	—
June	30.106	—	—	—	S'ly & W'ly	5.19	—	3.9	—
July	30.119	—	—	—	S to W	5.80	—	3.5	—
August	30.135	—	—	—	S to W	6.48	—	3.5	—
September	30.079	—	—	—	S'ly	7.52	—	3.6	—
October	30.043	—	—	—	N to E	7.84	—	4.2	—
November	30.011	—	—	—	E to N	8.21	—	4.9	—
December	29.943	—	—	—	E to N	8.46	—	5.4	—
Year Totals ...	—	—	—	—	—	86.16	—	—	—
Year Averages ...	30.046	—	—	—	S to E	—	—	4.7	—
Year Extremes ...	—	—	—	—	—	—	—	—	—

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.		Extreme Shade Temperature. Lowest.		Greatest Range.	Extreme Temperature. Highest in Sun.		Extreme Temperature. Lowest on Grass.		Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	21	21	21	21		21		21	21		21		—
January	8.55	69.0	77.3	108.9	14/02	58.8	4/93	50.1	162.7	20/89	49.9	4/93	—
February	84.3	68.6	76.5	101.9	11/04	58.7	†	43.2	158.1	10/88	49.3	9/89	—
March	82.1	66.5	74.4	96.8	16/88	55.6	30/95	41.2	160.0	1/87	46.0	28/02	—
April	78.7	61.4	70.1	95.2	*	48.6	17/00	46.6	148.7	2/87	37.0	17/00	—
May	73.1	55.2	64.2	88.8	18/97	41.3	24/89	47.5	140.8	4/88	29.8	8/97	—
June	69.2	50.6	59.9	81.5	6/06	38.5	16/96	43.0	133.9	6/06	25.4	23/88	—
July	68.1	47.7	58.0	83.4	28/98	36.1	‡	47.3	134.4	29/89	23.9	11/90	—
August	71.2	49.7	60.5	87 5	8/07	37.4	6/87	50.1	140.7	30/88	27.1	9/99	—
September	75.5	54.5	65.1	90.2	20/04	40.7	1/96	49.5	155.5	26/03	30.4	1/89	—
October	79.9	59 9	69.9	101.4	18/93	43.3	3/99	58.1	156.5	31/89	34.9	8/89	—
November	82.7	63.8	73.3	105.4	13/98	48.5	2/05	56.9	162.3	7/89	38.8	1/05	—
December	85.0	67.2	76.1	105.9	26/93	57.0	16/90	48.9	159.5	23/89	49.1	3/94	—
Year Averages ...	77.9	59.5	68.8	—		—		—	—		—		—
Year Extremes ...	—	—	—	108.9	14/1/02	36.1	§	72.8	162.7	20/1/89	23.9	11/7/90	—

* 9/1896 and 5/1903. † 10 and 11/1904. ‡ 12/1894 and 2/1896. § 12/7/1894 and 2/7/1896.

HUMIDITY, RAINFALL, AND DEW.

Month.	Humidity. Mean 9 a.m.	Humidity. Highest Mean.	Humidity. Lowest Mean	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.		Rainfall. Least Monthly.		Rainfall. Greatest in One Day.		Dew.* Mean Amount of Dew.	Dew.* Mean No. days Dew
No of yrs. over which observation extends	21	21	21	21	21	21		21		21		—	—
January	66	79	53	7.61	14	27.72	1895	1.23	1889	18.31	21/87	—	—
February	69	82	55	7.03	14	40.39	1893	0.77	1904	8.36	16/93	—	—
March	72	85	56	6.69	16	21.36	1890	0.63	1903	6.77	13/92	—	—
April	72	79	60	3.29	12	14.26	1892	0.05	1897	3.93	20/92	—	—
May	75	85	64	2.97	11	11.82	1903	0.47	1902	4.26	31/03	—	—
June	74	81	68	2.08	7	11.03	1893	0.02	1895	6.01	9/93	—	—
July	73	80	67	2.23	7	8.46	1889	0.04	1894	3.54	16/89	—	—
August	70	80	65	2.35	8	11.80	1887	0.24	1896	4.89	12/87	—	—
September	65	76	47	2.17	9	4.80	1890	0.10	1907	2.46	2/94	—	—
October	62	72	52	2.72	10	6.26	1892	0.14	1900	1.95	20/89	—	—
November	59	71	53	3.66	11	8.78	1889	1.07	1906	2.57	17/95	—	—
December	62	67	52	4.95	12	11.52	1895	0.55	1900	5.26	7/05	—	—
Year Totals ...	—	—	—	47.75	131	—		—		—		—	—
Year Averages ...	68	—	—	—	—	—		—		—		—	—
Year Extremes ...	—	85	47	—	—	40.39	2/1893	0.02	6/1895	18.31	21/1887	—	—

— Signifies no record kept. * Dew included in rainfall.

CLIMATOLOGICAL DATA FOR SYDNEY, N.S.W.

LAT. 33° 52′ S., LONG. 151° 13′ E. HEIGHT ABOVE M.S.L. 146 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m. & 3 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	49	49	49	49	49	49	49	49	49
January	29.929	721 1/71	0.35	8,010	N E	5.30	4.7	5.1	1.7
February	29.973	871 12/69	0.27	6,447	N E	4.22	3.5	5.4	1.2
March	30.054	943 20/70	0.23	6,473	N E	3.60	5.0	5.0	2.4
April	30.103	802 6/82	0.20	5,896	N E	2.49	4.5	4.6	2.5
May	30.091	758 6/98	0.20	6,046	W	1.58	3.6	4.3	3.3
June	30.089	712 7/00	0.28	6,893	W	1.26	2.7	4.7	2.7
July	30 115	930 17/79	0.26	6,978	W	1.20	1.9	4.1	3.5
August	30.103	756 22/72	0.24	6,678	W	1.50	3.2	4.4	3.7
September	30.045	964 6/74	0.27	6,844	W	2.50	4.8	4.3	3.0
October	30.001	926 4/72	0.29	7,284	N E	3.81	5.4	4.6	1.9
November	29.981	720 13/68	0.32	7,426	N E	4.68	6.4	5.2	1.0
December	29.918	938 3/84	0.32	7,629	N E	5.28	7.1	5.5	1.5
Year { Totals ...	—	—	—	—	—	37.42	52.8	57.2	28.4
Year { Averages ...	30.034	—	0.27	6,884	N E	—	—	—	—
Year { Extremes ...	—	964 6/9/74	—	—	—	—	—	—	—

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.	Extreme Shade Temperature. Lowest.	Greatest Range.	Extreme Temperature. Highest in Sun.	Extreme Temperature. Lowest on Grass.	Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	49	49	49	49	49	49	49	49	47
January	78.2	64.8	71.5	108.5 13/96	51.2 14/65	57.3	160.9 13/96	44.2 18/97	71.4
February	77.2	64.8	71.1	101.0 19/66	49.3 28/63	51.7	173.3 11/89	43.4 25/91	71.9
March	75.4	63.0	69.2	102.6 3/69	48.8 14/86	53.8	172.3 4/89	42.3 13/93	70.9
April	70.9	58.2	64.7	88 9 3/87	44.6 27/64	44.3	144.1 10/77	38.0 13/92	68.3
May	64.9	52.0	58.5	83.5 1/59	40.2 22/59	43.3	129.7 1/96	30.9 7/88	64.2
June	60.4	48.2	54.3	74.7 24/72	38.1 29/62	36.6	123.0 14/78	28.7 30/95	59.9
July	58.9	45.7	52.3	74.9 17/71	35.9 12/90	39.0	144.2 15/98	24.0 4/93	57.3
August	62.2	47.5	54.9	82.0 31/84	36.8 3/72	45.2	149.0 30/78	27.7 30/95	57.5
September	66.3	51.4	58.9	89 8 22/98	40.8 18/64	49.0	142.2 12/78	31.1 1/95	60.2
October	71.0	55.9	63.5	99.7 19/98	43.3 2/99	56.4	149.9 13/96	33.0 2/99	63.3
November	74.2	59 6	66.9	102.7 21/78	46.2 27/64	56.5	158.5 28/99	39.8 16/61	66.8
December	77.1	62.8	70.0	107.5 31/04	49.3 2/59	58.2	171.5 4/88	42.2 8/75	69.5
Year { Averages ...	69.7	56.2	63.0	—	—	—	—	—	65.1
Year { Extremes ...	—	—	—	108.5 13/1/96	35.9 12/7/90	72.6	173.3 11/2/89	24.0 4/7/93	—

HUMIDITY, RAINFALL, AND DEW.

Month.	Humidity. Mean.	Humidity. Highest Mean.	Humidity. Lowest Mean	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.	Rainfall. Least Monthly.	Rainfall. Greatest in One Day.	Dew. Mean Amount of Dew.	Dew. Mean No. days Dew
No of yrs. over which observation extends	49	49	49	49	49	49	49	49	49	49
January	71	78	60	3.56	14.2	10.49 1883	0.42 1888	3.75 22/63	0.002	1.1
February	73	81	60	4.88	13.9	18.56 1873	0.34 1902	8.90 25/73	0.003	1.4
March	75	85	63	5.09	14.9	18.70 1870	0.42 1876	5.66 25/90	0.007	2.9
April	78	87	64	5.63	13.5	24.49 1861	0.06 1868	7.52 29/60	0.022	6.3
May	76	90	66	5.21	15.8	20.87 1889	0.21 1885	8.36 28/89	0.030	7.3
June	79	89	72	5.49	12.7	16.30 1885	0.19 1904	5.17 16/84	0.022	5.3
July	77	88	66	4.74	12.5	13.21 1900	0.12 1862	4.77 9/04	0.024	6.8
August	74	84	64	3.22	11.6	14.89 1889	0.04 1885	5.33 2/60	0.021	5.7
September	70	79	60	2.97	12.3	14.05 1879	0.08 1862	5.69 10/79	0.008	3.4
October	68	77	55	2.97	12.9	10.81 1902	0.21 1867	6.37 13/02	0.004	1.6
November	68	79	58	3.10	12.6	9.88 1865	0.20 1867	4.23 19/00	0.006	2.7
December	68	77	59	2.50	12.9	7.80 1870	0.45 1876	2.75 1/88	0.002	1.0
Year { Totals ...	—	—	—	49.36	159.8	—	—	—	0.151	45.5
Year { Averages ...	73	—	—	—	—	—	—	—	—	—
Year { Extremes ...	—	90	55	—	—	24.49 4/1861	0.04 8/1885	8.90 25/2/73	—	—

CLIMATOLOGICAL DATA FOR MELBOURNE, VICTORIA.

LAT. 37° 50′ S., LONG. 144° 58′ E. HEIGHT ABOVE M.S.L. 91 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m., 3 p.m. & 9 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	50	41	41	41	41	36	—	50	—
January	29.933	583 10/97	0.30	7,412	S W, S E	6.34	—	5.2	—
February	29.985	566 8/68	0.28	6,488	S W, S E	4.96	—	5.1	—
March	30.070	677 9/81	0.22	6,409	S W, S E	3.83	—	5.5	—
April	30.122	597 7/68	0.19	5,750	S W, S E, N W	2.29	—	5.8	—
May	30.129	693 12/65	0.19	5,993	N W, N E, S W	1.49	—	6.5	—
June	30.098	761 13/76	0.24	6,531	N W, N E	1.11	—	6.7	—
July	30.125	755 8/74	0.23	6,539	N W, N E	1.08	—	6.3	—
August	30.083	637 14/75	0.26	6,906	N W, N E, S W	1.49	—	6.3	—
September	30.019	617 11/72	0.29	7,102	N W, S W, N E	2.28	—	6.1	—
October	29.986	899 15/66	0.30	7,412	S W, N W	3.28	—	6.0	—
November	29.998	734 13/66	0.29	7,144	S W, S E	4.50	—	5.9	—
December	29.919	655 1/75	0.31	7,540	S W, S E	5.72	—	5.5	—
Year Totals ...	—	—	—	—	—	38.38	—	—	—
Year Averages ...	30.039	—	0.26	6,769	S W, N W	—	—	5.9	—
Year Extremes ...	—	899 15/10/66	—	—	—	—	—	—	—

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.	Extreme Shade Temperature. Lowest.	Greatest Range.	Extreme Temperature. Highest in Sun.	Extreme Temperature. Lowest on Grass.	Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	52	52	52	52	52	52	48	47	—
January	78.1	56.5	67.3	111.2 14/62	42.0 28/85	69.2	178.5 14/62	30.2 28/85	—
February	77.7	56.6	67.1	109.5 7/01	40.3 9/65	69.2	167.5 15/70	30.9 6/91	—
March	74.6	54.5	64.7	105.5 2/93	37.1 17/84	68.4	164.5 1/68	28.9 †	—
April	68.6	50.7	59.7	94.0 6/65	34.8 24/88	59.2	152.0 8/61	25.0 23/97	—
May	61.5	46.6	54.0	83.7 7/05	31.3 26/95	52.4	142.6 2/59	23.2 21/97	—
June	56.9	43.9	50.4	68.1 *	28.0 11/65	40.1	129.0 11/61	20.4 17/95	—
July	55.5	41.5	48.5	68.4 24/78	27.0 21/69	41.4	125.8 27/80	20.5 12/03	—
August	58.8	43.2	51.0	77.0 20/85	28.3 11/63	48.7	137.4 29/69	21.3 14/02	—
September	62.5	45.3	53.9	82.3 30/07	31.9 13/07	49.8	142.1 20/67	24.7 13/07	—
October	67.0	48.1	57.5	96.1 30/85	32.1 3/71	64.0	154.3 28/68	25.9 3/71	—
November	71.3	50.9	61.1	105.7 27/94	36.5 2/96	69.2	159.6 29/65	24.6 2/96	—
December	75.3	53.7	64.5	110.7 15/76	40.0 4/70	70.7	170.3 20/69	33.2 1/04	—
Year Averages ...	67.3	49.3	58.3	—	—	—	—	—	—
Year Extremes ...	—	—	—	111.2 14/1/62	27.0 21/7/69	84.2	178.5 14/1/62	20.4 17/6/95	—

* 21/1865 and 2/1884. † 17/1884 and 20/1897.

HUMIDITY, RAINFALL, AND DEW.

Month.	*Humidity. Mean.	*Humidity. Highest Mean.	*Humidity. Lowest Mean.	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.	Rainfall. Least Monthly.	Rainfall. Greatest in One Day.	Dew. Mean Amount of Dew.	Dew. Mean No. days Dew.
No of yrs. over which observation extends	50	50	50	52	52	67	67	48	—	—
January	64	73	57	1.90	7	6.83 1844	0.04 1878	2.97	—	—
February	65	75	54	1.74	7	6.78 1841	0.03 1870	2.14	—	—
March	68	78	61	2.13	8	6.36 1874	0.16 1842	3.05	—	—
April	73	83	63	2.42	10	6.71 1901	0.57 †	4.50	—	—
May	79	86	70	2.14	12	6.94 1848	0.45 1901	1.85	—	—
June	80	88	75	2.05	13	5.22 1851	0.60 1840	1.74	—	—
July	80	88	74	1.85	15	7.02 1891	0.49 1840	2.71	—	—
August	75	81	65	1.81	13	7.62 1849	0.48 1903	1.87	—	—
September	72	81	63	2.31	14	5.87 1870	0.61 1881	2.62	—	—
October	71	79	63	2.69	13	7.61 1869	0.28 1850	3.00	—	—
November	67	75	59	2.26	10	12.13 1849	0.25 1895	2.57	—	—
December	65	75	55	2.27	9	7.18 1863	0.11 1904	2.36	—	—
Year Totals ...	—	—	—	25.57	131	—	—	—	—	—
Year Averages ...	72	—	—	—	—	—	—	—	—	—
Year Extremes ...	—	88	54	—	—	12.13 11/1849	0.03 2/1870	4.50	—	—

— Signifies no record. * Mean of 9 a.m., 3 p.m., and 9 p.m. readings taken. † 1866 and 1902.

CLIMATOLOGICAL DATA FOR HOBART, TASMANIA.

LAT. 42° 53′ S., LONG. 147° 20′ E. HEIGHT ABOVE M.S.L. 160 FT.

BAROMETER, WIND, EVAPORATION, LIGHTNING, CLOUDS, AND CLEAR DAYS.

Month.	Barometer corrected to 32° F. and Mean Sea Level from 9 a.m. & 3 p.m. Readings.	Wind. Greatest Number of Miles in one day.	Wind. Mean Hourly Pressure. (lbs.)	Wind. Total Miles.	Wind. Prevailing Direction.	Mean Amount of Evaporation.	No. of Days Lightning.	Mean Amount of Clouds.	No. of Clear Days.
No. of yrs. over which observation extends.	24	—	24	—	24	—	—	24	—
January	29.844	—	0.51	—	S E, N W	—	—	6.3	—
February	29.906	—	0.51	—	N W, S E	—	—	6.2	—
March	29.980	—	0.47	—	N W, S E	—	—	6.0	—
April	30.014	—	0.43	—	N W, S E	—	—	6.3	—
May	30.041	—	0.43	—	N W	—	—	6.3	—
June	29.958	—	0.43	—	N W	—	—	6.5	—
July	29.957	—	0.47	—	N W	—	—	5.8	—
August	29.949	—	0.47	—	N W	—	—	5.9	—
September	29.862	—	0.63	—	N W, S E	—	—	6.2	—
October	29.824	—	0.60	—	N W, S E	—	—	6.6	—
November	29.844	—	0.63	—	N W, S E	—	—	6.5	—
December	29.819	—	0.60	—	N W, S E	—	—	6.4	—
Year Totals ...	—	—	—	—	—	—	—	—	—
Year Averages ...	29.916	—	0.51	—	N W, S E	—	—	6.3	—
Year Extremes ...	—	—	—	—	—	—	—	—	—

TEMPERATURE.

Month.	Mean Temperature. Mean Max.	Mean Temperature. Mean Min.	Mean Temperature. Mean	Extreme Shade Temperature. Highest.		Extreme Shade Temperature. Lowest.		Greatest Range.	Extreme Temperature. Highest in Sun.		Extreme Temperature. Lowest on Grass.		Sea water mn. 3 ft. below surface.
No. of yrs. over which observation extends.	24	24	24	24		24		24	22		20a		—
January	70.8	53.1	62.0	105.0	1/00	40.3	2/06	64.7	160.0	‡	30.6	1897	—
February	71.0	52.9	62.0	104.4	12/99	39.0	20/87	65.4	165.0	24/98	28.3	1887	—
March	68.0	50.5	59.3	97.5	7/91	36.0	31/05	61.5	147.5	1/06	27.5	30/02	—
April	63.0	47.9	55.5	82.4	6/88	33.3	24/88	49.1	138.5	12/05	25.0	1886	—
May	57.6	43.3	50.5	75.3	3/88	29.2	20/02	46.1	128.0	1889	20.0	19/02	—
June	53.0	41.3	47.2	69.2	1/07	29.5	26/02	39.7	122.0	12/94	21.0	6/87	—
July	52.1	39.3	45.7	65.4	15/98	27.7	11/95	37.7	118.7	19/96	18.7	16/86	—
August	55.0	41.0	48.0	71.5	17/02	30.5	4/97	41.0	129.0	1887	21.0	1887	—
September	58.4	42.8	50.6	79.5	*	31.0	16/97	48.5	134.0	7/94	22.7	1886	—
October	62.7	45.1	53.9	86.0	29/07	32.0	12/89	54.0	146.0	1885	23.8	§	—
November	66.1	48.0	57.1	98.0	23/88	37.0	†	61.0	151.0	17/03	26.2	29/05	—
December	69.1	50.9	60.0	105.2	30/97	38.0	3/06	67.2	156.0	18/05	27.2	1886	—
Year Averages ...	62.2	46.7	54.3	—		—		—	—		—		—
Year Extremes ...	—	—	—	105.2	30/12/97	27.7	11/7/95	77.5	165.0	24/2/98	18.7	16/7/86	—

a Records only continuous since 1893.

* 30/91 and 17/97. † 24/84, 13/87, 11/85, and 7/00. ‡ 5/86 and 13/05. § 1886 and 1899.

HUMIDITY, RAINFALL, AND DEW.

Month.	Humidity. Mean 9 a.m.	Humidity. Highest Mean.	Humidity. Lowest Mean	Rainfall. Mean Monthly.	Rainfall. Mean No. of Days Rain.	Rainfall. Greatest Monthly.		Rainfall. Least Monthly.		Rainfall. Greatest in One Day.		Dew. Mean Amount of Dew.	Dew. Mean No. days Dew
No. of yrs. over which observation extends	13	13	13	64	50	64		64		25		—	—
January	63	72	55	1.84	9.0	5.91	1893	0.03	1841	2.59	30/05	—	—
February	65	76	51	1.50	7.8	9.15	1854	0.07	1847	1.60	22/03	—	—
March	69	76	63	1.61	8.9	7.60	1854	0.02	1843	1.45	1/83	—	—
April	76	84	69	1.76	9.8	5.01	1856	0.07	1904	1.66	22/01	—	—
May	80	85	72	1.85	12.0	6.37	1905	0.10	1843	1.62	31/05	—	—
June	82	92	75	2.15	12.8	8.15	1889	0.22	1852	4.11	14/89	—	—
July	79	88	73	2.16	13.0	5.98	1849	0.30	1850	1.56	8/94	—	—
August	79	82	71	1.80	12.1	10.16	1858	0.23	1854	2.28	13/90	—	—
September	75	82	65	2.10	13.1	7.14	1844	0.39	1847	1.57	24/85	—	—
October	69	75	63	2.13	13.7	6.67	1906	0.26	1850	2.58	4/06	—	—
November	65	76	57	2.57	12.1	8.92	1849	0.16	1868	3.70	30/85	—	—
December	60	73	56	1.88	10.4	9.00	1875	0.11	1842	2.27	27/07	—	—
Year Totals ...	—	—	—	23.35	134.7	—		—		—		—	—
Year Averages ...	72	—	—	—	—	—		—		—		—	—
Year Extremes ...	—	92	51	—	—	10.16	8/1858	0.02	3/1843	4.11	14/6/89	—	—

— Signifies no record kept.