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British Association.

Western Australia, 1914.

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Handbook and Guide

TO

Western Australia.

Prepared for the Members of the Advance Party of

The British Association for the Advancement of Science

on the occasion of their visit to Perth and the South-Western portion of the State, under the direction of the Local Publications Committee.

PERTH:

BY AUTHORITY: FRED. WM. SIMPSON GOVERNMENT PRINTER.

1914.

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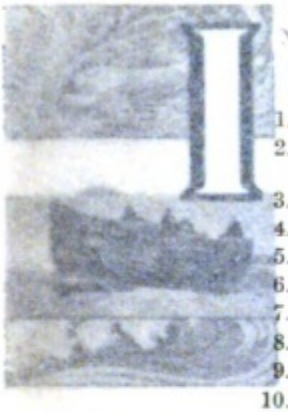
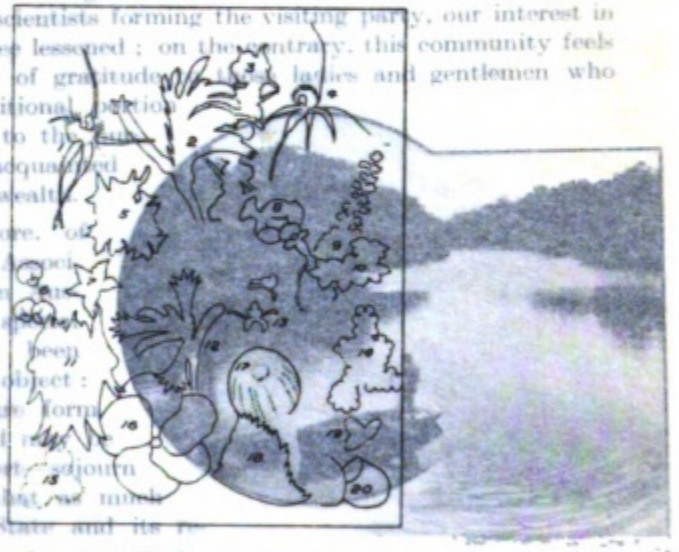
Introduction.



Wild Flowers of Western Australia.

1. *Caladenia Longicauda* (Spider Orchid).
2. *Anigozanthus Manglesii* (Red and green Kangaroo Paw).
3. *Hovea Trisperma* (Hovea).
4. *Caladenia Patersoni* (White Spider Orchid).
5. *Leschenaultia Biloba* (Blue Leschenaultia).
6. *Isotropis Striata.*
7. *Caladenia Flava* (Cowslip Orchid).
8. *Diuris Longifolia* (Stag's Head Orchid).
9. *Verticordia Grandis* (Crimson Verticordia).
10. *Burchardia Umbellata.*



11. *Clianthus Dampieri* (Sturt's Desert Pea).
12. *Anigozanthus Humilis* (Orange Kangaroo Paw).
13. *Caladenia Discoidea* (Small Spider Orchid).
14. *Chamaelaucium Uncinatum* (Wax Flower).
15. *Trichinium Obovatum* (Goldfields Clover).
16. *Hibiscus Huegelii* (Swan River Hibiscus).
17. *Banksia Coccinea.*
18. *Kennedya Nigricans* (Black and gold Kennedya).
19. *Thysanotus Dichotomus* (Fringed Lily).
20. *Cephalotus Follicularis* (Pitcher Plant or Fly Trap).

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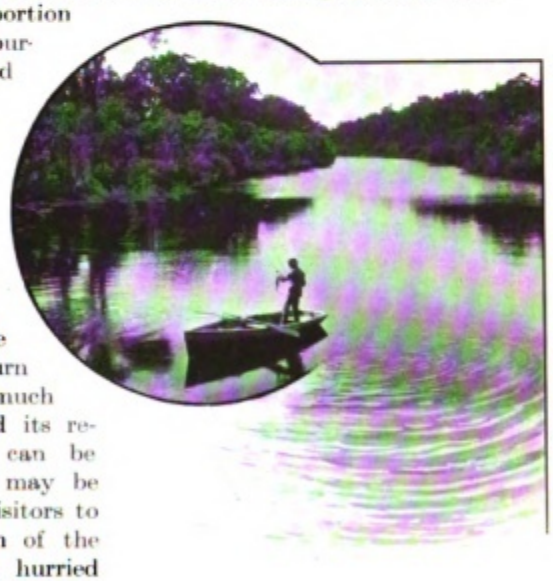
Introduction.*

IN writing a few introductory remarks to the unpretentious "Handbook of Western Australia," of which this forms a part, the mind is first of all impressed by the occasion which gives rise to its publication.

The approaching visit of the representatives of the "British Association for the Advancement of Science" to Australia, in order that their annual meeting for the year 1914 shall be held in this portion of the Empire, has given rise to wide-spread feelings of gratification, in which Western Australia, the youngest State in development though the largest in area, fully shares.

Though this State is not to be honoured by a visit from the whole body of scientists forming the visiting party, our interest in their movements is in no degree lessened; on the contrary, this community feels that it owes a special debt of gratitude to those ladies and gentlemen who have agreed to devote an additional portion of the time at their disposal to the purpose of making themselves acquainted with this part of the Commonwealth.

For the benefit, therefore, of those members of the British Association who have paid Western Australia the compliment of a special visit this little book has been prepared, and with a two-fold object: firstly, that it may in the future form a memento of what it is hoped may be a pleasant—though all too short—sojourn in our midst, and secondly, that as much information concerning our State and its resources, past, present, and future, as can be shortly expressed in these few pages, may be laid before our guests. Too often visitors to these shores gain a hasty impression of the whole of Western Australia from a hurried glance at the immediate surroundings of Perth and Fremantle, and while this may convey an accurate idea of what progress has been made, still the factors of that progress—the agricultural, the mining, the pastoral areas of the



WHERE ACCLIMATISED PERCH ABOUND.

* By the Hon. W. Kingsmill, B.A., M.L.C.

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State, lying in some cases at great distance from its commercial and political centre—are liable to escape observation.

It is intended in the present instance to obviate as far as possible such a state of affairs, but even though various excursions for our visitors have been arranged, it will be impossible for them to see more than a small portion of this State.

Those citizens of the Empire who find themselves by destiny, or choice, dwellers in Western Australia are inheritors of a vast territory.

Forming about one-third of the island continent, this State stretches from latitude 35° south to within 14 degrees of the Equator, and has a breadth from east to west of approximately 850 miles. The area thus comprised is very nearly a million square miles, or, to express the amount in a manner more striking by comparison, about eighteen times the area of England and Wales.

The coast line of such a State must necessarily be of great length, and this indeed is the case. For about 4,000 miles (neglecting minor indentations) the coast

ALBANY, UNITED STATES BATTLESHIPS IN THE HARBOUR.

of Western Australia stretches itself through tropics and temperate zones with all varieties of scenery, of geological conditions, of natural products. This coast, too, has a great historic interest, in that it formed for centuries at once the subject of speculation and despair to those navigators who sighted its apparently inhospitable sand-dunes or rocky heights.

De Gonneville early in the 16th century is generally credited with the discovery of Australia, and it is certain that West Australia would be the first land he sighted. Next came the Portuguese, and subsequently the Dutch, who gave the world of those days the first definite tidings of the great island with the desert shores.

Our coast is rich in names reminiscent of the Dutch navigators, and there now rests in the Museum in Antwerp the plate erected upon the northern end of the island, to which Dirk Hartog gave his name, by that sturdy navigator in 1616.

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The spot now bears the name of Cape Inscription, and instead of the rough post supported by a cairn of stones of Hartog's time, a modern lighthouse now warns the sailors of to-day that a turning point in their voyages southward or northward, as the case may be, has been reached.

Next the English made a somewhat belated appearance, and Dampier, erstwhile buccaneer, but voyaging to Australia as the fully accredited representative of the British Admiralty, made a landing in the neighbourhood of Sharks Bay, where he engaged in the hopeless task of endeavouring to find water for his ships. He sailed along a considerable extent of the coast, and formed so poor an opinion of it as to deter, by his official reports, further effort in the direction of exploratory work for many years.

GOVERNMENT GARDENS, PERTH.

It is perhaps not to be wondered at that even the stout-hearted navigators of the 16th and 17th centuries should have felt a shock of disappointment when, after months of sailing stormy seas, invested in their imaginations with all the horrors of the unknown, with their blood, rendered sluggish by the poison of scurvy, scarce coursing through their veins, with bones racked by the stiffness of confinement on their ridiculously inadequate little vessels, at last the long-expected land is reached and found to be forbidding in appearance and inhospitable on closer acquaintance ; for Australia in general, and Western Australia in particular, do not turn the best side nor the pleasantest aspect to the ocean.

Too often landings were made where no water was to be found, where game was scarce, and natives hostile, and impressions were formed which postponed the settlement of Australia for centuries.

It is well perhaps for the British race that this was so, otherwise this island continent would have been lost for ever to the Empire.

To resume our interrupted glance at the history of the West Australian coast after Dampier's discouraging accounts, the French were next to endeavour to pierce the mystery of the unknown land, but, as before, the barrier of the coast lands restrained them. Baudin in the North and La Perouse in the South, each did good service in charting roughly the sandy beaches and rocky headlands, but it was not till 1826 that, acting under orders from the Governor of New South Wales, Major Lockyer landed at the Albany of to-day, and formally took possession of the western side of Australia for England.

This step was taken through apprehension that the French, who were known to have closely examined the southern portion of this State, harboured designs of annexing it.

In 1829 the first actually practical steps towards settlement were taken. Governor Stirling landing close to the present position of Fremantle formed the

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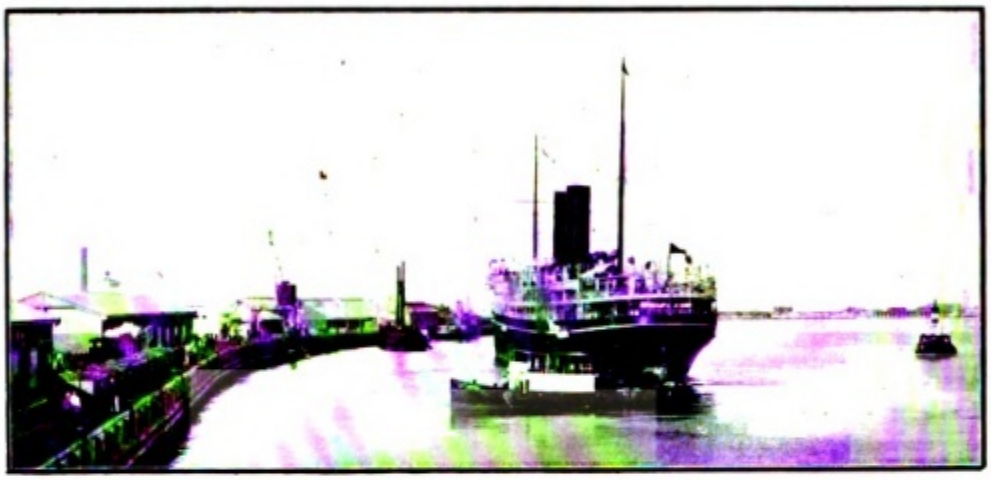
Swan River settlement and proclaimed a colony. Gradually, very gradually, the handful of settlers made progress in their enormous task of turning to account the huge area placed under their control. South and north along the coast in sparsely scattered communities the pioneers made good their footing. Eastward with difficulty a track was found through the ranges which divide the sandy coast lands from the beautiful arable country lying inland. And so, slowly, step by step, through privations and dangers of drought and natives resentful of the occupation of their land, Western Australia forged ahead, in so far as her pastoral and agricultural industries were concerned. The pastoral areas of the North-West were opened up, and the natives gradually won into the service of white



BERTHING A MAIL STEAMER AT FREMANTLE.

masters. Kimberley received the nucleus of the herds of cattle which now exist there, principally from overlanders, who, like the Shepherd Kings of old, travelled from far away New South Wales and Victoria—with stock increasing on the long, slow journey, in some cases taking two years to accomplish.

Inland from Perth, from Geraldton, from Albany, the farmers, when not occupied with the culture of their then scanty crops, roughly explored the back country in search of sandalwood, which was then the principal export.

More scientific exploration was being carried out by Grey, by Gregory, by Warburton, by the Forrest brothers, and by others whose names are less heard of than these.

And all these tardy, faltering steps of progress were but the introduction to the period when Western Australia, under the magic influence of gold, first began really to move.

First to far off Kimberley the news of gold discoveries brought thousands of people from the Eastern States, and even from New Zealand. In many cases the new arrivals, discouraged by reports from the fields situated from two to three hundred miles inland, over difficult tracks, went no further than Derby or Wyndham, the ports of West and East Kimberley respectively. Others, making greater efforts, won through to the new discoveries, in some few instances to do

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well, but as a rule to find that remoteness and richness are not always synonymous terms when applied to gold discoveries.

Some two years later gold was found at Yilgarn, close to the present position of Southern Cross, and as the years went on, link by link the golden chain which binds the North and South was forged, till now from Kimberley through Pilbara, Ashburton, Peak Hill, Murchison, Kalgoorlie, Norseman, Ravensthorpe, from coast to coast, a line of goldfields reaches.

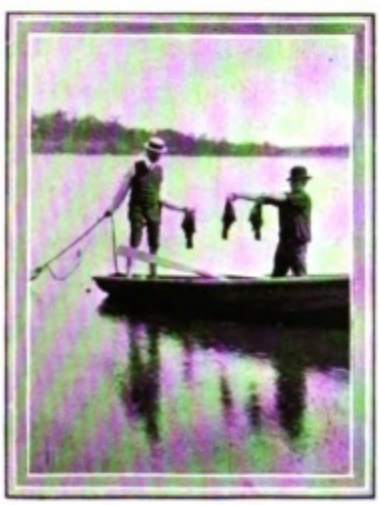
Of these the crowning glory was Kalgoorlie, the Golden Mile, which was responsible for the inrush of population, which in a very few years quadrupled the population of the State by the advent of young, vigorous and venturesome men from various parts of the globe.

It is unnecessary to do more than to allude to our mineral wealth, which will be dealt with as a special subject later.

DURBAR SPRING, ON THE WILUNA-HALL'S CREEK STOCK ROUTE.

A further brief reference to the far-stretching coast line of the State may perhaps be permitted. It has already been stated that the nature of this coast furnished for many generations an impassable barrier to settlement, and while this is undoubtedly the case, it is no less true that, whether regarded from a purely scientific or an economic point of view, the coast of Western Australia is intensely interesting. Strange to say, so far as scenic effects are concerned, the least visited portions are the most attractive.

In the south the sea-scapes formed by the bold granite capes and sheltered bays from Albany eastward to the hundreds of islands, large and small, of the Recherche Archipelago, are equalled in few parts of Australia.



In the distant North, from Derby to Wyndham, precipitous red sandstone cliffs, with a tropical growth taking advantage of what available soil there is, render the journey between these two ports a beautiful one; and everywhere islands as in the South, most of them bearing names reminiscent of the French navigators who followed one another down this portion of the sea board. And to add a further excitement to navigation, we have the wonderful tides. At Fremantle the rise and fall of the tide is almost negligible, thence northward a gradual increase takes place till North-West Cape, one of the corners of Australia, is reached; then the tides increase amain till at Derby, situated far up the inlet known as King's Sound, into which the Fitzroy River empties, a rise and fall at Spring tides of no less than thirty-six feet occurs.

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One who has seen the large volume of water contained in the Sound rushing through the narrow passages, such as Escape Pass, or Pearl Pass, formed by the islands which lie across the mouth of this inlet, will not readily forget the scene. The rugged nature of the sea bottom combines with the speed of the current (which is such that none of the coasting boats attempt to stem it) to form an almost appalling series of whirlpools, tide-rips, rapids, and eddies, which no doubt will some day be harnessed by engineers and devoted to the peaceful service of mankind.

ST. GEORGE'S TERRACE, PERTH.

Along the chain of islands fringing the coast may be found many remarkable instances of the influence of environment upon species. Practically every group of islands contains one or more highly specialised varieties of marsupials non-existent elsewhere, and it is to be regretted that in some instances the representatives of these species have been allowed to disappear without specimens having been obtained in greater numbers.

Turning to the economic aspect of the coast, we find two industries in full swing, and can easily believe that more will follow.

In the latter half of the last century the south-west and south coast were favourite whaling grounds, and many a cargo of oil has been won by the hardy Yankee whalers from Cape Cod and Martha's Vineyard, who frequented these waters, while the ruins of trying out plants for boiling down blubber may still be

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seen at various sheltered spots. To-day we find that, after languishing and lying dormant for thirty years or so, the whaling industry is being revived, on this occasion by Norwegian craft. Two whaling stations have been established within the last year or two, one at Point Cloates, about 500 miles north of Fremantle, and the other at Albany, and from each of these depôts at different seasons of the year the whaling boats set out, not, as in years gone by, lumbering, greasy, evil-smelling sailing vessels, but smart high-powered small steamships, each armed with a murderous bomb gun mounted in the bows, fitted with wireless telegraphic appliances, and possessing a speed more than equal to that of their quarry. In this pursuit the element of sport, such as it is, has been eliminated and the element of profit correspondingly increased.

The other industry to which allusion has been made is that of pearling, which has been carried on along the coast for about forty years altogether with fine results. Two principal centres of this industry may be shortly noticed. At Sharks Bay, the scene over two hundred years ago of Dampier's futile search for water, the beginning of Western Australian pearling took place. The shell raised at Sharks Bay is quite different from that occurring farther north. This species of pearl oyster is small in size, with a comparatively thin shell, and is distinguished by bearing large numbers of small pearls, both free and also embedded in the flesh of the oyster. It is found on shallow banks, so shallow indeed that in many cases the shell is picked up by men wading across the banks; it occurs thickly, so much so that in the deeper portions of the shell-bearing ground a small iron dredge is used for obtaining it. The banks are leased to various owners, and readily respond by increased yields to a rough sort of cultivation.

KING KARRI, 242FT. HIGH, 40FT. GIRTH.

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consisting principally of breaking up the clusters into which untended shells are apt to join. The principal centre of the industry is the little town of Denham, where most of the shell obtained is treated for pearls. The fish taken from the shell is placed in a large open boiler known as a "Pogy Pot," wherein, by a judicious alternation of putrefaction and cooking, it is induced to yield up its valuable contents. The resultant odour, while apparently innocuous and even beneficial to the residents of Denham, is extremely embarrassing to the casual visitor.

A PEARLING FLEET.

The other branch of the pearling industry deals with a much larger and finer species of pearl oyster, and has a sphere of operation extending north and east of North-West Cape, with Broome as the principal commercial centre.

The shell is large and heavy and brings a big price in English and Continental markets. The pearls too, while not occurring with anything like the frequency of those in Sharks Bay, are much more valuable. It is hard to say what is the highest price that has been given for a gem on that portion of the coast, but it is known that on one occasion over £5,000 was paid for one pearl sold in Broome.

This industry employs nearly five hundred boats, and approximately four thousand men—most of them Malays and Japanese.

The habitat of the shell ranges from coral and other reefs exposed at low tide to greater depths than it has been found possible to reach with the most modern diving appliances, and extends along the coast, roughly speaking, from North-West Cape to Derby, a distance of nearly 1,000 miles.

In times gone by, the North-West portion of our coast was exploited by the Malays for the trepang or bêche-de-mer which exists in favourably situated banks, and though this pursuit is not at present carried on, there is without doubt a sufficient quantity of this product available to render the starting of such an industry probable at any time.

Within the last few years a large English firm have obtained concessions over the foreshore of portion of the coast in the vicinity of Onslow for the purpose of

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utilising the edible turtles which are found thereon in great numbers, and which it is their intention to export to London.

From various parts of the coast, ranging from Esperance in the South-East to Broome in the North-West, specimens of sponges of high commercial value have reached the Fisheries Department of the State. So far no systematised attempt has been made to place the industry on a business footing, but no doubt with the advent of population this and other new avenues of employment will be opened.

Perhaps enough has now been mentioned about the proved, as well as the potential resources of her shores to demonstrate that, in her immense coast line, Western Australia possesses an asset of no mean importance.

To a body of visitors who must be from the nature of their associations concerned in educational matters, a brief outline of the progress of the movement in Western Australia may possibly prove interesting.

For many years after the establishment of the colony, in 1829, the education of the young was left entirely to private enterprise. In 1871, however, a beginning was made with a system of State education, which has developed very considerably and satisfactorily since that date. Under the Elementary Education Act, 1871, provision was made for the control and government of education throughout Western Australia by a body known as the Central Board, acting directly under the Governor of the then Crown colony. The Statute also provided for the creation of district boards and for the appointment of inspectors.

CENTRAL SCHOOL, PERTH.

It was rendered possible for the Crown to give financial assistance to elementary schools controlled by private persons or associations where the fees did not exceed the modest sum of one shilling weekly. The education provided was strictly secular. For more than twenty years this system of primary education held sway, but two years after power of self government was bestowed on Western Australia, in 1891 an Act was passed abolishing the Central Board and providing in its place a Ministerial head, known as the Minister of Education.

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Attendance at the State schools was made compulsory where children lived not more than three miles from such a school. In 1895 the scheme of assistance to elementary schools before alluded to was terminated, and the then Government paid to the representatives of the schools receiving assistance the sum of £15,000 as compensation for the assistance lost. Other gradual modifications brought the system of primary education up to its present level.

A SCHOOL GARDEN.

It has always been found that in a country of such exceptionally magnificent distances as Western Australia, the administration of the Education Department has been particularly difficult and costly, but successive Governments, recognising that the existence of an efficient scheme of education formed one of the greatest inducements to prospective settlers, particularly in the sparsely populated districts, have spared neither expense nor trouble in this direction. The annual expenditure to-day on education (neglecting the amount spent in the construction of school buildings) is no less a sum than £319,312, or almost exactly twenty shillings for every man, woman, and child in the State. For this sum a comprehensive curriculum is provided, and nearly the whole of the amount is expended on primary education. In addition to the ordinary subjects usually taught, it has been found possible at all the larger centres for the boys to receive instruction in what is known as manual training, while the girls have an opportunity to qualify themselves for the duties of adult life by learning cookery and domestic economy. There are no teaching fees for primary education.

Having regard to what has been done to provide secondary education for the State, it will be found that here, too, an early beginning was made, firstly, of course, by private enterprise.

In the year 1876, however, it was found that very many of the more wealthy of the colonists were in the habit of sending their sons out of the State to receive

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their education, principally to the large secondary schools which had already been successfully started in the Eastern States. The then existing Government, to obviate this, initiated by legislation the educational institution then and ever since known as the High School of Western Australia. This school is administered by a board of Governors appointed by Executive Council. It received a financial grant in 1876 of £700, diminishing to a fixed maximum of £500 two years later. In 1897 it was found necessary to increase this maximum to £1,000 per annum, at which amount it now stands. The tuition fees at this school must not exceed £12 per year. The State has been particularly liberal in granting land for school sites to the High School.

In addition to this State-aided school several other secondary schools, such as the Christian Brothers' College, the Scotch College, and the Guildford Grammar School conduct successful operations in Perth or its vicinity, while other schools are available in the larger centres of population outside the capital.

In 1900, the State again made an important addition to its educational system by the facilities for technical education. What is known as the Perth Technical School was started, with classes under specialists, wherein arts, crafts, and trades of various kinds could be taught. This step was so keenly appreciated that technical schools were found necessary in most of the principal towns of the State, and the principal problem to-day confronting the Department is the provision of sufficient commodious buildings and of qualified specialists to cope with the ever-increasing numbers of would-be students. About the same time also it was found advisable to provide a Training College, in order that teachers for the primary schools should therein be taught the most modern methods of imparting knowledge,

PRINCESS MAY SCHOOL, FREMANTLE.

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and this institution, which is prettily situated at Claremont, has been providing a three years' course of training to the maximum number for which accommodation can be found since its initiation.

In 1911 the Government of the day having come to the conclusion that in addition to the assistance given to the High School some further extension of secondary education was necessary, the Perth Modern School came into being, and the facilities therein provided have ever since been eagerly availed of, till to-day the fine building situated in one of the best parts of the City is taxed to its utmost to meet the needs of the boys and girls who are taking their education past the primary stage. In this Institution also no fees for tuition are charged, while admission is decided by annual competitive examinations.

For many years past it had been realised that the time was fast approaching when the final step should be taken for the completion of the educational system of the State by the creation of a University, and as far back as the year 1904 an Act passed the Legislature providing for the setting aside of certain lands of the Crown for the purpose of furnishing revenue in years to come for the nascent University.

PERTH MODERN SCHOOL.

Later a Royal Commission was appointed to fix the lines upon which the University should be governed, and upon which its teaching should be conducted. Subsequent to the presentation of the carefully considered report of this Commission, an Act for the establishment of the University of Western Australia was passed through the Parliament of the State. Therein it was enacted that the governing body of the University should primarily be the Senate, one-third of which (after the

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first appointments) should be nominated by the Government of the day; the remaining two-thirds being elected by Convocation, which body consists of graduates of the Western Australian and other Universities, other persons fitted by educational diplomas to occupy such a position, benefactors of the University and a representative of the Guild of undergraduates, the existence of which is foreshadowed and legalised in the University Act.

MANUAL TRAINING CLASS.

Already a most auspicious start has been made with this new seat of learning—a numerous and apparently particularly well selected staff of Professors and lecturers has been appointed, the number of students enrolled has delighted even the most sanguine supporters of the movement, and in a word, this, the coping stone of the Western Australian system of education, has been well and truly fitted to its place, and completes an edifice of which the State may well be proud.

The Government has been generous in the University Act in the direction of making worthy financial provision for the needs of its latest charge, and already signs are not wanting, by the provision of a Chair of Agriculture by the generosity of the Chancellor, Sir Winthrop Hackett, that private endowment which has done so much for similar institutions in our sister States will not fail to play the same part in Western Australia. To-day we have the satisfaction of possessing a system of education which permits the passage of a boy or girl from the Kindergarten stage to that of a graduate of the University without the payment of any tuition fees whatever, so that we may fairly claim to have done our duty to those who are growing up amongst us.

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It is perhaps somewhat late to endeavour to explain away and apologise for the extremely desultory nature of this introduction, and to account for the frequency with which changes of subject occur. It will be found, however, by those who are kind enough to peruse this little volume that later on therein special subjects are dealt with by specialists in those subjects, and it has therefore been deemed advisable to allude in these introductory remarks to those matters which are known not to be so provided for. At the same time it is not claimed that with the amount of space available all those things deserving the attention of our visitors can possibly be here dealt with. To give only one example, the timber industry of the State, with the large amount of capital (principally English) invested, with its export of hardwoods in various forms to all parts of the world, and its busy centres of industry throughout our South-West country, might well be exhaustively dealt with were it not for the fact that a large portion of the country to be traversed by those of our visitors whose researches will take them into the field, forms the scene of operation of its industry.

It is not to be denied, however, that this State has a most engrossing problem to solve in arriving at the best method of dealing with her timber resources, and the opinions of those fresh from parts of the world where this subject receives more than the passing attention paid it here, will be awaited and welcomed.

Nothing further remains than to commend to the kindly consideration of the members of the British Association for the Advancement of Science this handbook, which it is hoped, as already stated, will serve a dual purpose ; firstly to afford them some little information before and during their visit, and secondly, to serve as the means of arousing what we trust may be pleasant reminiscences when their visit is but a memory.

On behalf of the people of Western Australia it gives those in whose hands has been placed the carrying out of the arrangements for the Western Australian portion of the visit, the greatest pleasure to wish our coming guests the warmest of welcomes.

PARLIAMENT HOUSE, PERTH.

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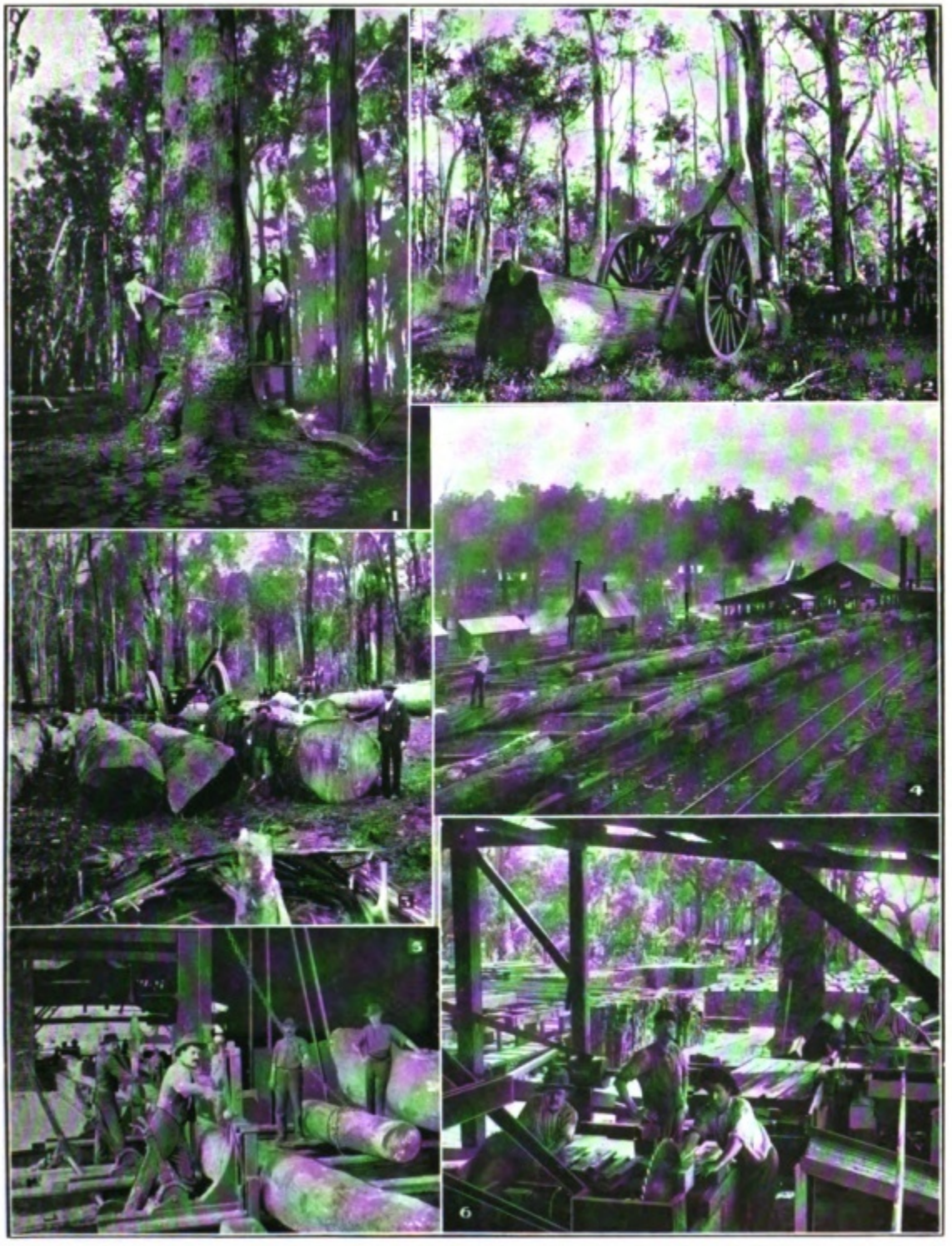

PHASES OF THE TIMBER INDUSTRY.

1. FELLING A FOREST GIANT.
2. HAULING TO THE TRAMWAY.
3. A BUSH SIDING.
4. THE SAWMILL.
5. BREAKING DOWN.
6. STREET PAVING BLOCKS FOR LONDON.

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Agriculture in Western Australia.*

IT is unfortunately necessary to attempt the impossible by endeavouring to give an outline of agriculture in Western Australia in a space inadequate to deal with one of its many features. Not being endowed with the powers of the mythical Æolus who confined the winds of Heaven in an ox hide, the writer has endeavoured to prepare a few notes which will serve as an introduction to the official figures and details in the hand books available at the Departments of Lands and Agriculture.

The Swan River was visited in 1837 by Captain Stirling, accompanied by Mr. Charles Fraser, Government Botanist of New South Wales, and in his report the former said:—"In delivering my opinion on the whole of the lands seen on the banks of the Swan, I hesitate not in pronouncing it superior to any I have seen in New South Wales eastward of the Blue Mountains, not only in its local situation, but in the many existing advantages which it holds out to settlers." Stripped of detail these included: The superiority of the soil, the open state of the country, the abundance of fresh water springs and water carriage.

This enthusiastic report, combined with the decision of the Home Government to grant settlers one acre of land for every half-crown in money or goods they brought to the colony, led to a rush of land-seekers when the Swan River Colony was established in 1829. It was soon found that the alluvial banks of the Swan and other streams were not typical of the greater part of the country, which was secured in immense blocks by the pioneer genuine settlers and speculators, many of whom soon left the colony, and their lands in some cases remain practically in their virgin condition to-day.

In almost every part of Australia the first stage of development has been the utilisation of huge areas of unfenced natural pastures for stock. The word "squatter," which is now synonymous with a pastoralist or grazier on a large scale, originally meant a man who occupied, with his cattle and sheep, land which had not so far become alienated from the Crown by purchase or lease. The general prevalence of forests with their undergrowth of innutritious natural vegetation, the absence of large areas of natural pasture, and the presence of poison plants unfitted the south-west of Western Australia for development on these lines. Thus the State, which is perhaps the richest in species and individuals of the unique plants which are of such absorbing interest to the botanist, for that

* By W. Catton Grasby, F.L.S.

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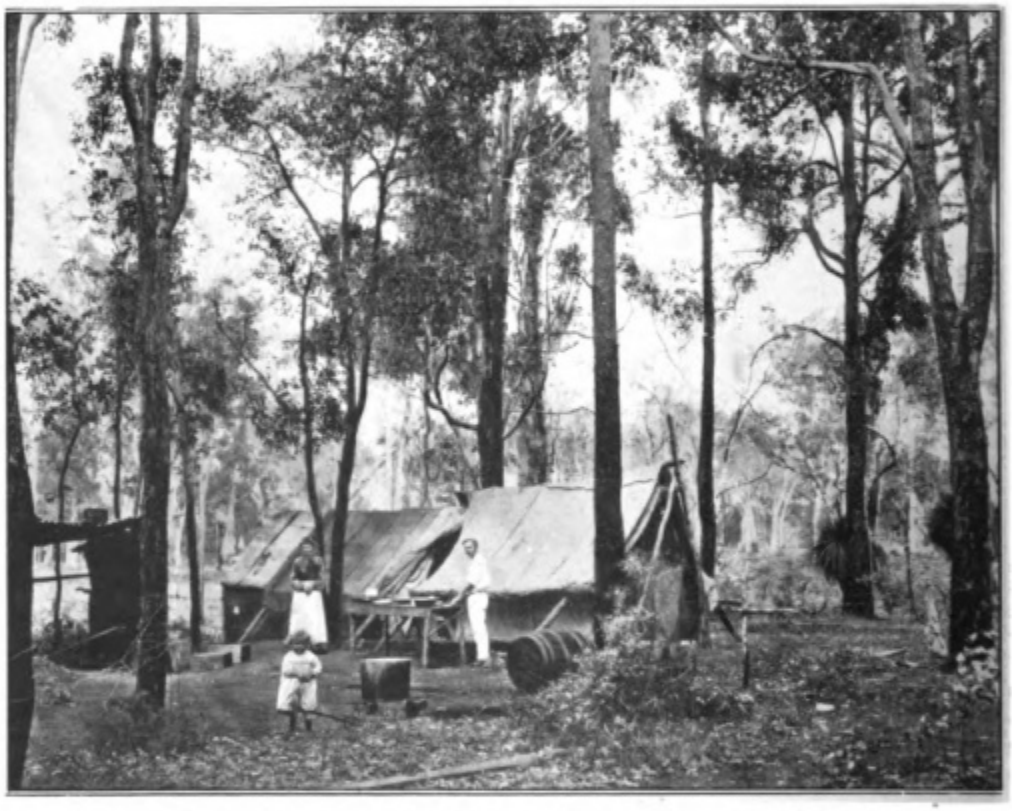
reason became the Cinderella of the Australian group of colonies until the discovery of her golden slipper, or, more literally, gold mines. Payable gold was found in Kimberley, in the north of the State, in 1885. Discoveries at Southern Cross some 230 miles east of Perth were made in 1887, and at Coolgardie and Kalgoorlie in 1892 and 1893, and were followed by the stirring times of the "roaring nineties," as a result of which Western Australia came into her inheritance as an agricultural State.

Up to this time the population was under 40,000, the people were scattered over wide areas, and agriculture, practically confined to very limited areas, was prosecuted only for local needs. Small power and even hand flour mills were to be seen at many homesteads, barter was the common method of trade, and practically the only agricultural exports were wool and skins. It is necessary to bear these facts in mind in order to understand that although settlement took



LIFE'S GREATEST SUCCESSES HAVE OFTEN HUMBLE BEGINNINGS.

place 85 years ago, it is only 20 years since the modern development of our agricultural industry began. It took from 10 to 12 years to remove old prejudices and misconceptions, so that popular belief in Western Australia as an Agricultural State, and the consequent vigorous development of her lands, is only eight or 10 years old. This point cannot be too strongly emphasised.

With the discovery of gold, people flocked from all corners of the earth to mine or to provide for the needs of the gold seekers. A demand arose for all kinds of agricultural produce, meat, grain, milk, butter, fruit and vegetables, to provide

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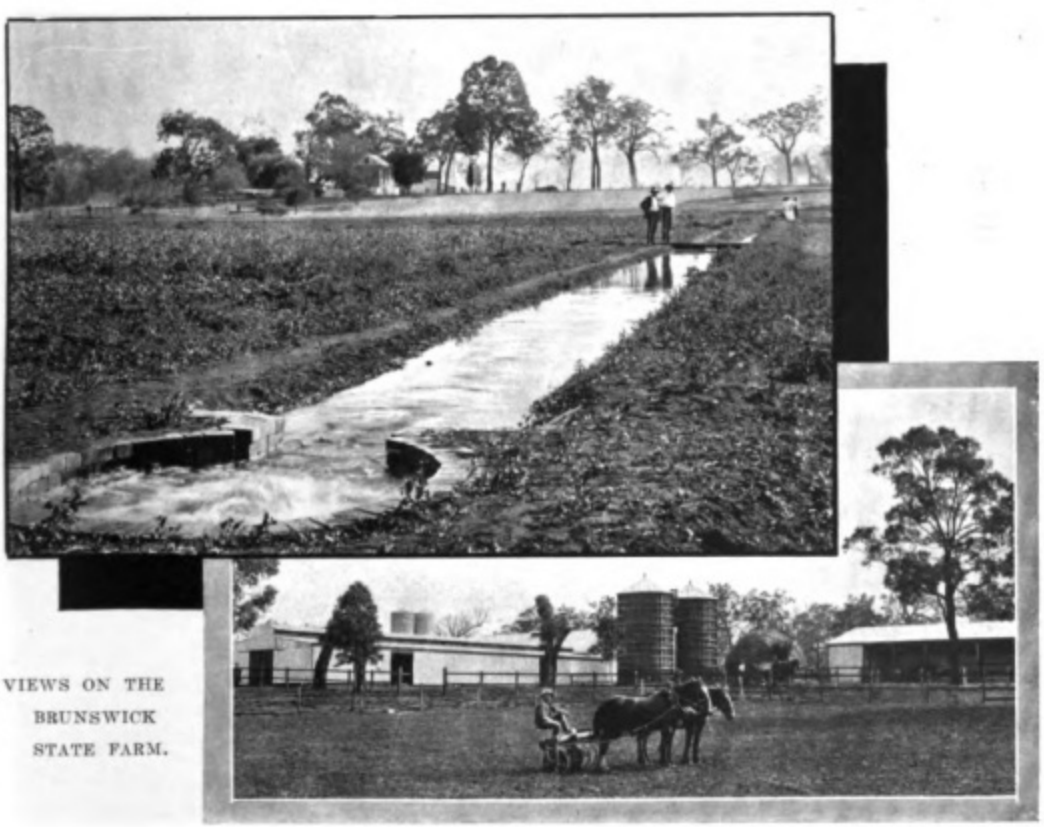
for which local supplies were entirely inadequate. In respect to dairy produce the statement still applies. Disappointed gold-seekers turned market gardeners, fruit-growers and farmers. Tempted with the high price of grain and hay, men familiar with the conditions of the wheat-growing country of South Australia and Victoria quickly proved that the forest soils of the table-land east, north, and south of the old-established farming districts of Northam, York, and Beverley, were capable of producing wheat and oats for hay and grain, and that the land when cleared and cropped became valuable pasture. In this way what is destined to be the biggest wheat belt of Australia was opened up. The following table shows the development of wheat-growing :—

Year.	Acres.	Production.	Average per acre.
		bushels.	
1890	33,820	467,389	13·8
1913	1,104,753	13,496,242	12·2

It may be confidently anticipated that in two or three years the production will reach 20 million bushels, and within a further 10 years or so the 50-million mark should be reached, with corresponding increase in other farm crops.

Similarly the wonderful suitability of a million acres of the heavily timbered lands on the hills and south-west of the agricultural areas for fruit-growing was



VIEWS ON THE BRUNSWICK STATE FARM.

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demonstrated. In the early nineties the fortunate owner of a small orchard found himself in possession of unexpected wealth. Apples were purchased by dealers on the trees at 9d. per lb. The planting of fruit trees was undertaken as rapidly as the clearing of the heavy timber would permit, and, when a few years ago, the production of apples overtook local needs, the magnificent quality of the fruit secured for it at once the top price on the London and German markets. The acreage under fruit trees and vines is approximately 24,000 acres ; but the

A SHELTER CLUMP OF GIMLET TREES IN A WHEAT FIELD.

effective bearing area is much less. Last season some 70,000 bushels of fruit, chiefly apples and grapes, were exported, and this year the total is expected to be over 120,000 cases, and it must increase by leaps and bounds as the orchards reach the full bearing stage.

The total area of the State is a little short of one million square miles. What may be the agricultural future of the larger portion, no man can say. At present available water supplies are the controlling factors in preventing settlement ; but no one can study the fairly abundant natural vegetation over scores of millions of acres of the interior without coming to the conclusion that, although the rainfall is limited and not regular, abundant natural waters are non-existent and wells of fresh water hard to find, it is not drought country in the strict sense, and desert is the last word that should be applied to it. The visitor to the Eastern goldfields travels through hundreds of miles of salmon gum forest and prolific scrub country which cannot be distinguished by the untrained observer from the best wheat lands. Twenty years ago the limit of safe farming country was set at a little east of Northam, or say 70 miles from the coast. Old settlers who then thought it was madness to attempt to farm at Meckering, 89 miles from the coast, are able to appreciate the success of their sons at Merredin 80 miles still further inland.

Leaving out the interior, where the absence of water so far prevents stocking and cropping, pastoral and more strictly agricultural settlement is confined to a

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coastal fringe of varying width. North of the Murchison river, or say 28 deg. S. Lat., the settled country is held under pastoral leases in large areas and is devoted to cattle and sheep. The extreme north, known as the Kimberley country, is chiefly used for cattle, and south of that is the North-West pastoral country, where sheep constitute the chief stock, but cattle are kept in large numbers. This

EWES AND LAMBS ON A MURCHISON STATION.

huge Nor'-West area includes the local districts, named after the chief rivers as the DeGrey, the Ashburton, the Gascoyne, the Murchison country and so forth. In the North and North-West there are approximately 4,000,000 sheep and 800,000 cattle.

The South-West.

South of the river Murchison is what is generally broadly spoken of as the South-West of the State. This section includes all the agricultural areas ; but within this great division the term south-west is applied with a more limited meaning. Thus the railway running south from Perth to Bunbury and Busselton is known as the South-West railway, and when the term south-west is used in connection with agriculture, it means in the popular sense all the country served by this line and its branches.

The Great Southern.

Similarly the railway between Beverley and Albany, originally built by a land company, is known as the Great Southern line, and all the country served by this line and its branches is known as the Great Southern country, the qualifying terms east of or west of the Great Southern being used for greater exactness. For further local definition the names of the chief towns, the spur railways, and the principal physical features are used.

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The Eastern Districts.

In the same way that big section of the wheat belt north and south of the Eastern Goldfields railway and its branches from York to Merredin is spoken of as the Eastern districts, and, at the present time, is the best developed of our wheat areas.

The Midland and Victoria Districts.

The country served by the Midland Company's railway is known as the Midland country ; that served by the port of Geraldton is best known by the name of its port, although it is more correct to call it the Victoria district.

These explanations are given because general settlement is so new that a good deal of confusion exists, and it is well for the visitor to study the map and make himself acquainted with the above sections of the country and the important centres. Thus Mt. Barker on the Great Southern railway, some 40 miles from Albany, and Bridgetown, some 59 miles by rail south-east of Bunbury, are continually mentioned as the chief centres of the apple growing industry, although apples are produced commercially here and there over an immense area.

The Wheat Belt

Is a term in common use and refers to a strip of country say 500 miles in length from the Murchison on the north to the south coast east of Albany. At its northern end it touches the coast, and is perhaps 30 miles wide. At the latitude of Perth it commences say 50 miles from the ocean and extends inland, having an approximate known width of 120 miles. Southward it increases in width, and at its southern end extends eastward, probably to near the border of South

SCOOPING OUT A TANK.

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Australia. No man can at present define its limits even approximately, because the rainfall records have been kept for too short a time to be a reliable guide.

So far pioneer methods prevail; in fact, the present wheat-growing industry has been developed on the most crude cultivation, but so regular is the winter rainfall in normal years that the results have justified the methods. In 1910 the writer inspected some 12,000 acres of crop in the Dowerin district and saw one plough and heard of one other which, however, had not been used. In reviewing the position he remarked :—" If one judged by this year's results he might say, ' the worse the farming the better the crops.' " During the past season that district has produced little short of one million bushels of wheat. In 1912 a farmer in the Midland district is stated to have averaged 20 bushels per acre over 2,000 acres without a plough. The good luck with that crop established him and he will only crop fallow in future. This year one of his fields averaged over 40 bushels over 202 acres. The pioneer endeavours to get the timber burned up in February and March, runs a cultivator over the friable virgin soil, drills in 60lbs. of seed and from 30 to 80 lbs. of superphosphate on the dry soil and waits for the rains and the harvest. With from 10 to 15 inches of rain nicely distributed from May to October, anything from 10 to 30 bushels may be harvested by this treatment of virgin land. Settlers realise that this is not farming. In the drier country the risk is too great, and although there are hundreds of examples where from three to six crops averaging 12 bushels per acre have been taken from land in the same number of years without ploughing the land, the gospel of bare moisture conserving fallow is almost universally accepted, and crude pioneer methods are only followed long enough to gain from the virgin land the capital to establish a farm. Every year the area of fallow is being increased, and each year an increased number of farmers are getting their holdings in a condition where they can keep sheep and crop once in three years. Under the climatic and economic conditions in the wheat belt this is the only practical rotation at present open to them. The increase of sheep on the farms is nearly as pronounced as the advance in wheat production, and the export of mutton and lambs must come in a few years. In the districts of greater rainfall more elaborate systems may be and are being adopted ; but these notes

FARM AND ORCHARD AT BALINGUP.

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refer to things as they are and not as they might be, and will be in years to come. It is absolutely necessary for the visitor to endeavour to realise what this brief and incomplete summary of the conditions means. Until he is able to grasp the magnitude of the splendid enterprise, the labour and the capital involved in changing forests into farms, he will of necessity misjudge. Above all he must remember the importance of time as a factor in the improvement of agricultural lands. He must also bear in mind that railways and roads rarely reveal the best in agriculture in any country. Western Australia is often spoken of as a land of magnificent distances, and in traversing them the thought must occur to the visitor that the improved lands are mere specks in the vast expanse of forest and scrub. All that can be said is that agriculture is in its infancy, but its possibilities have been proved, and its development is only a matter of time.

A COUNTRY STATION.

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A HARVEST PICTURE AT KATANNING, ON THE GREAT SOUTHERN RAILWAY.

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Irrigation.

No large irrigation schemes are yet in operation, but a number are contemplated. Owing to the fact that the hilly districts of the South-West have a remarkably regular and heavy rainfall, varying from 33 inches at Perth, to 40 inches farther south, the conservation of water is easy, and it is in the districts with a good rainfall that irrigation will be the more general. The remarkable fact about the rainfall is that on the average 90 per cent. falls during the seven months from April to October, so that the growth of summer crops is only practically without irrigation on the numerous areas of moist land which are swampy in winter. These lands are immensely increased in value by drainage and irrigation in the dry summer. During the past five years a rapid and gratifying development of individual schemes of irrigation has taken place especially south of Perth, and there is immense scope for further progress which is sure to take place. Without irrigation, lucerne cannot be grown on a large scale; but with irrigation it grows the whole year, although to a lesser extent in winter. It is common on well cared for fields to secure eight cuts in the 12 months. In the same way, owing to the absence of summer rains, the conditions of the South-West of Western Australia are not suited for maize, but with irrigation it thrives and gives heavy returns. What has been done so far is an indication of the possibilities and a sure forecast of the development of the future.

PERMANENT POOL AT RIVERSDALE.

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INCREASE IN POPULATION AND IMPROVED LAND.

Year.	Population.	Under Crop.	Land in Fallow.	Area Improved.
		Acres.	Acres.	Acres.
1900	179,000	201,338	44,116	1,218,902
1905	254,779	327,391	81,441	2,129,356
1910	276,832	722,086	284,267	4,685,607
1913	320,000	1,199,991	639,582	6,714,585

FRUIT TREES AND VINES.

Owing to rapid developments exact figures are not available with regard to the present area under vines and fruit trees, but the following may be taken as approximate. The major portion of the trees being young, the export figures must increase with great rapidity in the next few years.

The vine-growing industry has had a set back owing to competition with the old established vineries of the Eastern States, but this is past; the export trade in grapes is causing rapid planting, and the production of grapes and wine must increase rapidly.

Year.	Area under Orchards.	Exports of Fruit.	Area under Vines.	Production of Wine.
	Acres.	Cases.	Acres.	Gallons.
1900	4,465	*Nil*	3,245	113,799
1905	9,756	240	3,413	185,070
1910	15,909	11,000	2,917	140,559
1913	19,064	72,000	3,010	149,132
1914	?	120,000	?	?

"CHERRYDALE," IN THE DONNYBROOK FRUIT AREA.

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2. The rainfall steadily decreases from the south to the north and from the west to the east, without materially interfering with the proportional winter and summer distribution, although inland local thunderstorms increase the summer percentage. This concentration of the rain over the cool growing season of the year is of the greatest importance in connection with the future of the State as a producer of cereals and sheep, and is the basis of the fact that probably no country in the world is capable of producing wheat profitably on as low an average rainfall as this State.

3. The change from summer to winter conditions is usually so distinct that it is easy to fix the date when the winter may be said to begin. This is not determined by temperature or actual rainfall alone, but by a careful consideration of several factors shown on the weather map. The date may vary from the first week in April, which is rare, to the beginning of June, which is equally unusual. The average date is about the first week in May.

4. Perhaps the third most outstanding feature of the climate is the evenness of the temperature, its mildness, the absence of sudden changes, and the average dryness of the atmosphere in summer. Various complex factors operate, but in the main, the dryness is the natural corollary of the absence of summer rain, the mildness in winter is due to latitude, while the moderate temperature in summer is influenced by the depressions which pass from west to east over the ocean south of Australia in summer and always bring cool changes which creep slowly over the south-west of the State. It is also necessary in this connection to consider the influence of the Antarctic current which splits off the Leeuwin, one portion bathing the western coast, and providing the reason why surf bathing is not as general here as at Sydney; the other sweeps eastward and gives Albany and its neighbourhood its unique climate. This part of the State has a mean yearly temperature of 60 degrees, or five degrees lower than Adelaide, which is practically in the same latitude. In January, February, and March its mean is 65 degrees, which corresponds to that of Southern Victoria and the north coast of Tasmania, while in June, July, and August, the mean temperature of 55 degrees corresponds with Sydney.

ON THE MURRAY RIVER.

5. The conditions of the summer climate of the coastal district are modified by the dry land breezes which blow at night and the strong sea breezes which usually come in about mid-day and blow through the afternoon and evening.

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6. East of the Darling Range the country consists of an undulating tableland, with an elevation of from, say, 800 to 1,500 feet above sea level, and here the climate is more of a continental character with higher summer temperatures, colder nights, and more bracing winters.

7. The average maximum day temperature at Perth from November to March is about 80 degrees, while the extremes may vary from 42 degrees to 108 degrees, high temperatures always being associated with warm north-east winds and extremely dry atmospheric conditions.

The winter mean maximum temperature is about 65 degrees, while the mean minimum is 49 degrees, with extremes varying from 34 to 90 degrees. Only once has the minimum thermometer in the screen at Perth registered an air temperature as low as 34 degrees, which was on May 11, 1914. In some places the minimum reading on the ground on this occasion registered seven or eight degrees of frost, and under some purely local conditions probably 10 degrees. This is the only occasion known when the cold was severe enough in the coastal district to injure orange trees, and the injury done in this case was confined to young trees in a more or less vigorous condition of growth at the time.

For complete information of the climate of Australia the reader is referred to the publications of the Commonwealth Bureau of Meteorology, particularly "The Climate and Weather of Australia," by H. A. Hunt, Commonwealth Meteorologist, Griffith Taylor and E. T. Quail (1913). The Presidential Address by Professor David, D.Sc., F.R.S., C.M.G., before the 1913 meeting of the British Association for the Advancement of Science deals largely with the influence of Antarctica on the climate of Australia.

A GROVE OF APRICOT TREES.

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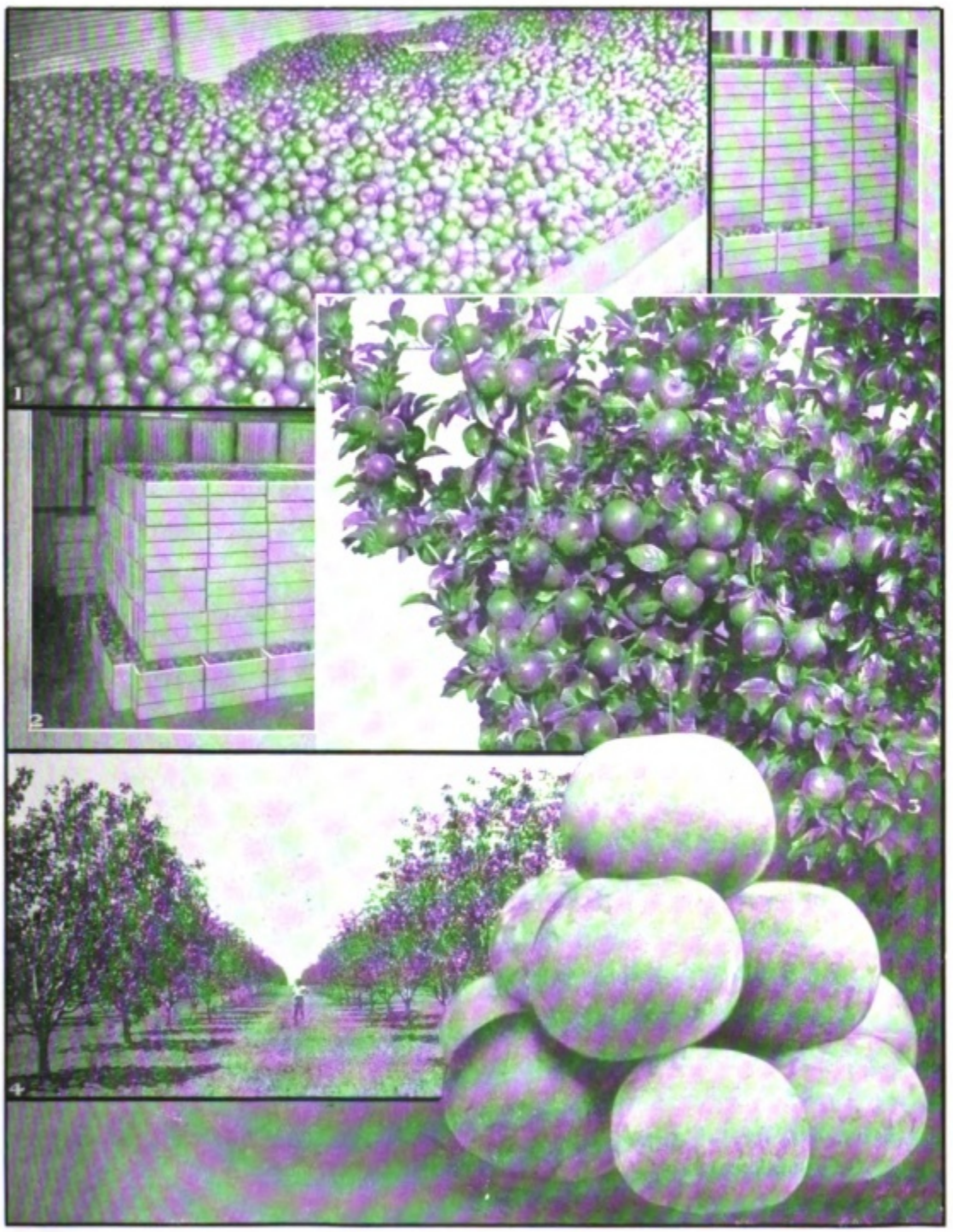

THE APPLE INDUSTRY.

1. £300 WORTH OF APPLES. 2. PACKED FOR LONDON. 3. SKILFULLY GROWN, THE TREES BEAR THEIR BURDEN BRAVELY. 4. HALF-MILE AVENUE OF APPLES.

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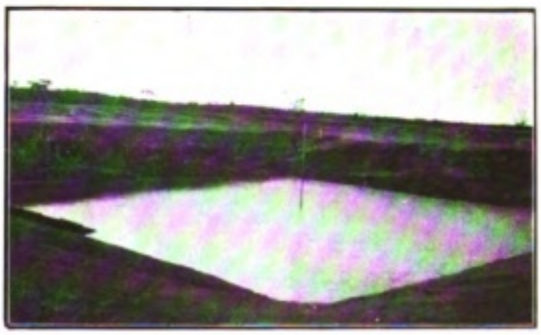
The Mineral Industry of Western Australia.*

THE most important natural product of the State of Western Australia, up to the present time, has been minerals, constituting quite three-fourths of the value of all its exports since the beginning of 1900, and nearly one-third of the total mineral production of all Australia during the same period. The principal mineral has been gold, which has been raised to the value of approximately £115,000,000 to end of 1913, but copper ores and furnace products, tin ores and smelted tin, and coal have also been of importance, reaching total values exceeding £1,000,000 in each case, while lead and silver together account for exports of over £700,000. Smaller values of antimony, asbestos, bismuth, cobalt ore, diamonds, ironstone, limestone, mica, plumbago, pyrites, scheelite, tantalite, wolfram, and zinc are also included in the Mines Department's returns of minerals exported, to which reference should be made for all statistics of the State's mineral production. Numerous other useful metals and minerals are known to exist in the State also, which have not been exported in commercial quantities.

The Ore Deposits: Geological Considerations.

Minerals are very widely distributed over the State, the metallic ore-deposits being principally in rocks of great age, mostly at least pre-Cambrian, which occupy about one-third of the 975,920 square miles of its area. These old rocks are a complex of very ancient metamorphic and igneous rocks of much variety of facies and commonly strongly plicated and foliated by tectonic earth-movements, which have been invaded by great granitic extrusions which constitute the greater part of the whole area in question. There is considerable probability that the granitic masses and the after-actions succeeding their extrusion have a close genetic connection with the ore deposits, for it is a notable characteristic of all the prin-



A GOLDFIELDS DAM.

*By A. Montgomery, M.A., F.G.S., State Mining Engineer.

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cipal primary deposits of metalliferous ores of the State that they are found almost exclusively in areas of "greenstone" and schist close to the contacts of these with the granite. Occasionally metalliferous veins are found also in the granite country near the margins of the two sorts of rocks, but rarely, if ever, have they been known to be in the granite at any considerable distance from these. The ore-deposits themselves mostly belong to types which most probably are of deep-seated origin, the ore-bodies having apparently resulted from metasomatic replacement of pre-existing country rock more characteristically than from deposition in open spaces, and very generally occurring in "lode-formations" which appear to comprise all possible variations and combinations of the "sheared-zone," "fissure-zone," and "shattered-zone" types of lode structure. Typical "fissure-lodes" are quite uncommon, the prevailing types of lode-structure being apparently due most likely to pneumatolytic penetration of lode-forming material through the more or less unevenly compacted broken rock formed along fault-planes as a result of faulting friction combined with strong pressure, rather than to free circulation of solutions in more or less open fissures.

ALLUVIAL WORKERS.

The lodes as now known to us are thus probably originally deep-seated portions of mineral veins, exposed by enormous denudation of once superincumbent rock, and of great antiquity of date of formation. They often show features best explainable by the supposition that later earth-movements subsequent to the formation of the ore-bodies may have caused renewed faulting movements along the old planes of weakness, with consequent disruption of the ore-veins and deposition of later vein-matter of different character. Recognition of the conception of the mode and circumstances of origin of the lodes just outlined will often serve to explain characteristics which otherwise appear anomalous to observers whose experience has been principally with the "fissure-vein" type of lodes.

Subsequent to the planing down by erosion of the mass of country of which the old rocks now exposed must have been the deep-lying portion—with probable formation of a very ancient peneplain—these old rocks appear, in course of geological time, to have been more or less covered by later sedimentary strata of many different ages, most of which have been since denuded again from the southern half of the State. With the exception of the Nullagine series of rocks, which have been tentatively classed at various times as Devonian and Cambrian

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without much positive or satisfactory evidence for either classification, and which contain very interesting auriferous conglomerates possessing features closely similar in many essentials to the "banket-reefs" of South Africa, the post-Cambrian rocks of the State have not been found to carry primary metallic ores in commercial quantities, with the exception perhaps of brown iron ore and bauxite. Phosphate rock has been found in small quantities, and may be yet got in important deposits, and deposits of gypsum of great extent are in the vicinity of existing or recent salt lake basins. The only highly important commercial mineral, however, in the post-Nullagine formations, so far as yet known, is coal, and as yet the worked deposits of this mineral are practically confined to the one small district of the Collie Coalfield (Permo-carboniferous). Coal has also been found in the Irwin River District, and may yet be brought to light in the somewhat extensive areas of country known to be of permo-carboniferous age in the Kimberley and Gascoyne Districts. Brown coal has also been found in several places in the coastal strata of probably Tertiary age.

THE DRYBLOWER.

Superficial "alluvial" deposits of gold, tin-ore and tantalite, have been also of considerable commercial importance. The term "alluvial," however, is not used in quite the same significance as regards concentration by running water as when employed in connection with the typical alluvial gravel deposits of Eastern Australia, but covers various superficial detrital concentrations of gold and tin-ore resulting from weathering erosion of the underlying old rocks. Some of these deposits have been carried into watercourses and concentrated there to some extent, but in many other cases they are simply the insoluble and heavy residual parts of the rock after extreme weathering of its felspathic and ferromagnesian constituents has brought about the removal of these in solution and by rain and wind as fine mud and dust. These deposits are very commonly enclosed in or covered by laterite, resulting from chemical concentration at surface of the iron in the underlying weathered country.

Among the alluvial deposits of both gold and tin ore are a large number of very interesting "deep leads" of somewhat uncertain age, though probably post-Tertiary, some of which have been of very considerable industrial importance. They often run 100 or more feet below the lake basin plains constituting the present surface, and are due to an older set of physiographical conditions than those which have given the surface its present shape. They generally have a fairly well defined "gutter" with more or less waterworn pebbles in it showing fluviatile concentration of a weak type, but more marked than is usual in the surface water-courses of the goldfields of the present day, and over the "gutter" lie bedded clays, or "pug," usually capped by one or more layers of concretionary brown iron ore which the present writer is disposed to regard more usually as "bog iron ore" deposits than "laterite." The extreme interest of these deposits lies in the fact that they often contain fine crystalline gold, usually of very high

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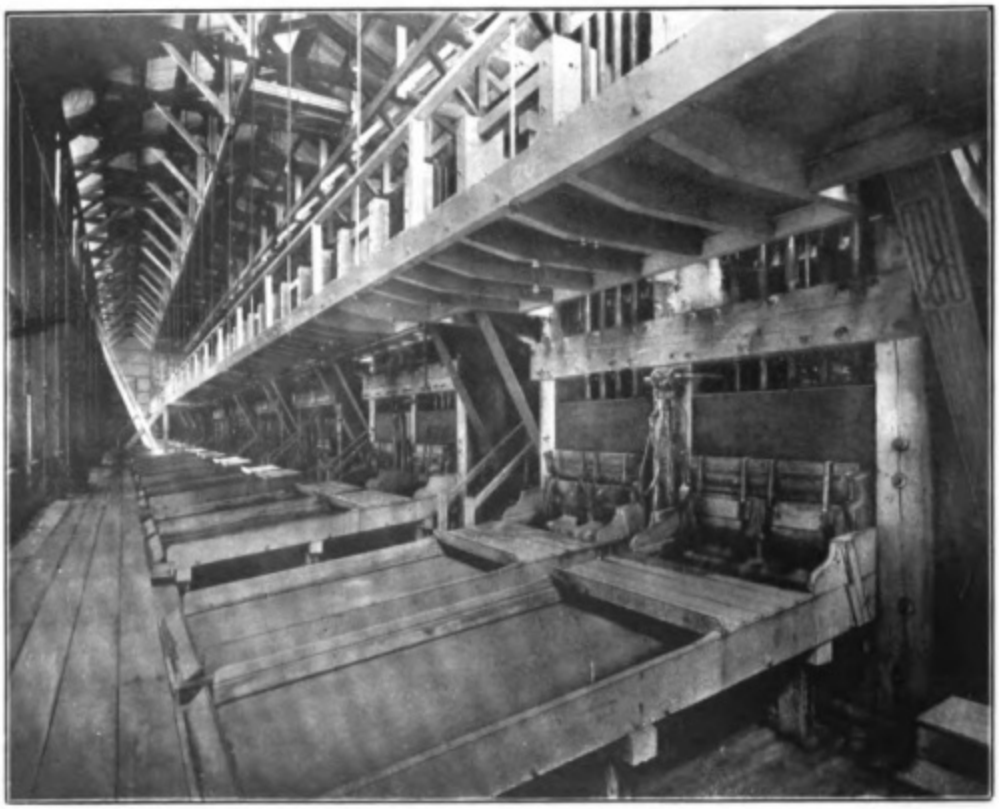
assay fineness, in sufficient amount to be commercially workable. Sometimes the gold is mainly in the ironstone, at other times in the "pug," and usually in fine crevices and joints of the latter. At times the auriferous layers are 30 to 50 feet above the "gutters." Similar gold is also found quite frequently in the weathered bedrock under the gutters, but gradually disappears as the rock becomes harder in depth. The conclusion is irresistible that the gold has been permeating in solution through the soft superficial ground, whether bedrock or detrital, and has been precipitated in favourable localities. Several instances are recorded in which roots of living trees penetrating into the "pug" have been found to be surrounded by deposits of fine crystalline gold, and pyrites plated over with gold on the crystal faces is also not uncommon. Solution of the gold probably is facilitated by the constant presence of large quantities of salt in the surface soil.

Quite similarly, the superficial weathered portions of auriferous lodes, especially those of clayey character, frequently exhibit a good deal of secondary chemical concentration of gold in them, characterised by a much higher degree of assay fineness of the gold than is found in the metal obtained in the deeper portions of the lodes.



A MILL WITH 100 HEAD OF STAMPS.

Detailed descriptions of most of the gold and mineral fields of Western Australia have been published in the Bulletins of the Geological Survey, and other publications of the Mines Department. Bulletin 50 of the Geological Survey gives a general synopsis of the geology of the State, and of its mineral industry.

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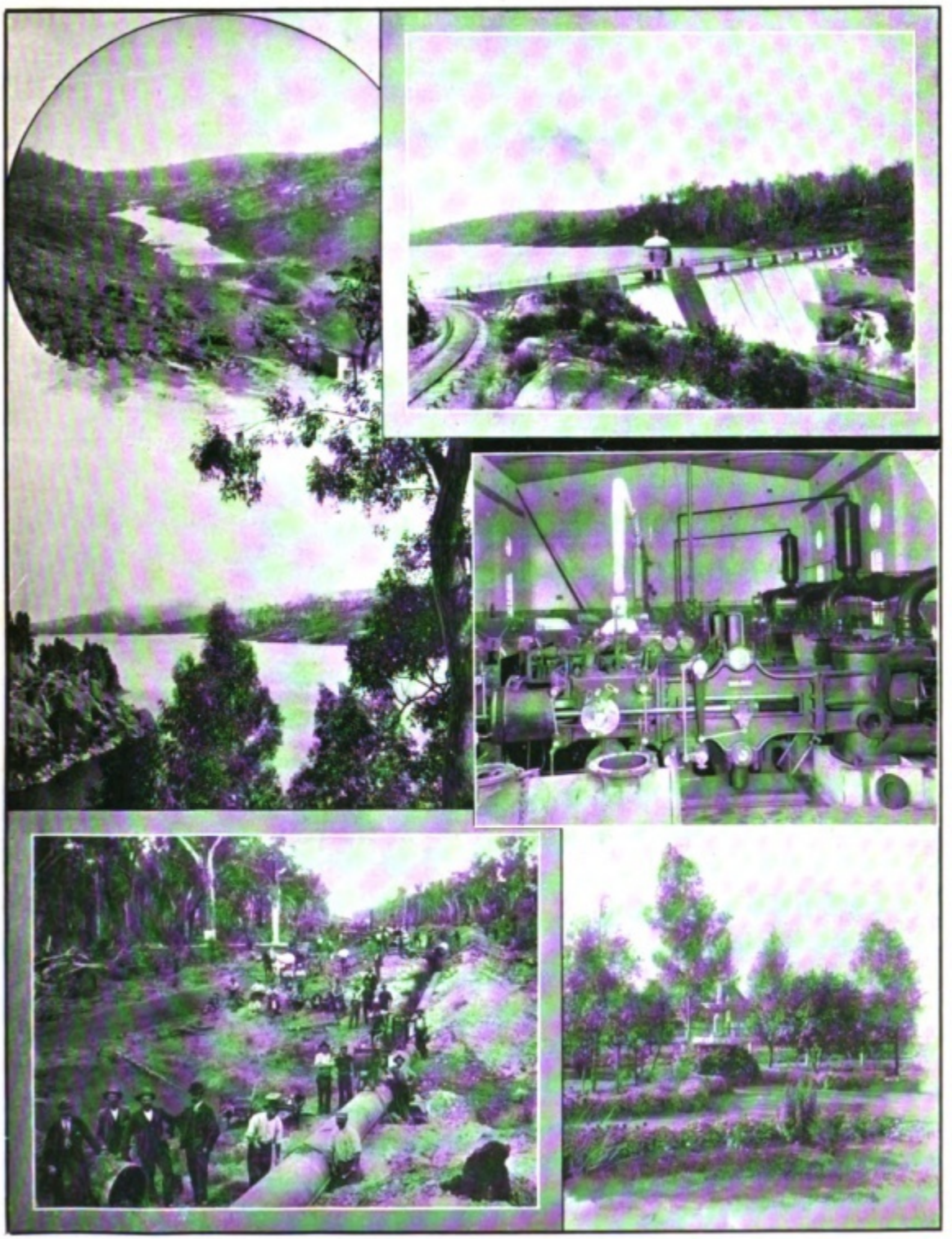

A WORLD-FAMED PUMPING SCHEME.

A GROUP OF PICTURES OF THE GOLDFIELDS WATER SCHEME, SHOWING THE ORIGINAL SITE OF THE RESERVOIR, THE MUNDARING WEIR, THE SEVEN-MILE LAKE OF IMPOUNDED WATER, ONE OF THE PUMPING STATIONS, SECTION OF THE PIPE MAIN, AND ONE OF THE GARDENS IN THE INTERIOR MADE POSSIBLE BY THE SCHEME.

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of Mines for 1912. Another table therein on page 10 shows that the total dividends to the end of 1912 were £22,992,515, and on page 11 it is shown that the dividends paid by gold mining companies have averaged 21 per cent. of the total production, and nearly 24 per cent. of the companies' own production. The average value of gold produced per man employed above and below ground for 1912 was £403·58.

Silver.—There is practically no mining done in the State for silver by itself, and most of this metal which is produced is separated from the gold. A small

MANY OF THE PRINCIPAL MINING CENTRES ARE ALMOST ENTIRELY SUPPORTED BY ONE MINE.

amount of silver lead-ore has been exported from the Ashburton district, and a little silver is got when smelting the copper ores of the Phillips River, Murchison, and Pilbara fields.

Copper.—Ores of copper are fairly well distributed through the State, but as a rule have been very little worked in most places except so far as obtaining small parcels for export to determine the industrial value of the ore. In West Pilbara, Northampton, and Phillips River fields, however, the production of copper is of quite considerable importance. At Phillips River fairly large smelting works are in operation.

Pyrites.—Cupriferous pyrites for manufacture of sulphuric acid have been mined in some quantity in the Mount Morgans District, and large supplies of pyrite and pyrrhotite have been proved to exist under iron cappings in the South Yilgarn and Phillips River fields.

Lead Ore.—Lead ore containing very little silver or gold is obtained in considerable amounts in the Northampton District, and argentiferous lead ores in the Ashburton field. A little galena is common in the gold-bearing lodes.

Tin Ore.—The principal centres at which tin ores have been worked are in the Greenbushes and Pilbara fields, in both of which tin is found both in veins and as alluvial ore. The veins are generally pegmatitic. Tin ore also has been found, however, in several other parts of the State, usually close to the margins of granitic intrusions into old schist country.

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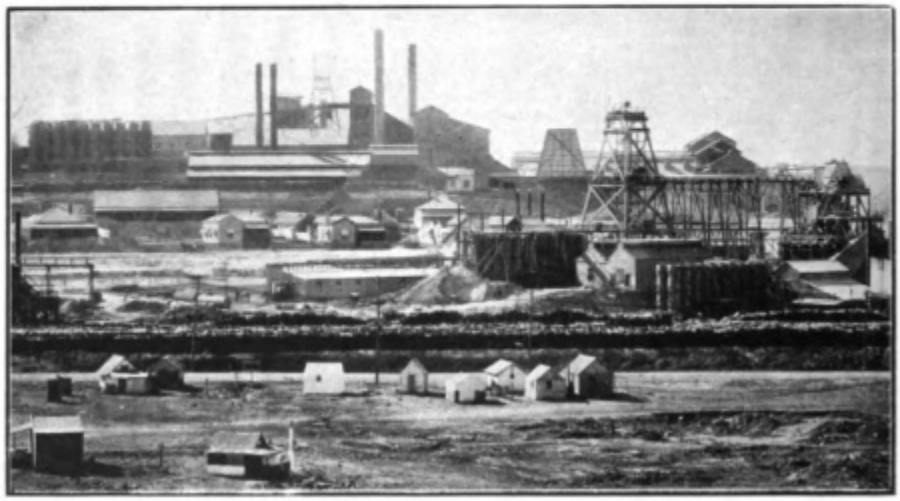
Wolfram, Bismuth Ores, Molybdenite, Tantalite, Pitch Blende, and Thorium Minerals have been found also under much the same conditions of occurrence as the tin ores, and often accompanying these. The tantalite discovery at Wodgina appears to be the most important one of this mineral yet made anywhere.

Antimony Ores are not unfrequent in small quantities all over the goldfields, but have not been exported for this metal except from the Pilbara and



THE GOLDEN MILE COMPRISES A WONDERFUL GROUP OF BONANZAS.

West Pilbara fields. There are no important mines of antimony in the State at present, however.

Arsenic, as arsenical pyrites, is rather common in several of the goldfields associated with gold, but has not yet been made commercially available except on a very small scale. There is some likelihood that it will be exported on a larger scale very shortly.

Zinc occurs fairly plentifully with the lead ores of Northampton as blende, of which sundry small parcels have been exported.

Asbestos.—Very fine samples of this mineral have been found in the Pilbara goldfield, and a small tonnage has been extracted for export, but without leading to the starting of a payable mine. The mineral is of the chrysotile variety, and of excellent quality.

Mica.—Samples of this mineral also have been obtained and exported from several localities in the State, without leading as yet to successful mining operations. Some of it is very good muscovite, of good electrical quality. Near Coolgardie there is also lepidolite in fairly large sheets, but valueless for electrical insulation on account of its fusibility.

Scheelite is very frequently found in association with auriferous quartz throughout the goldfields, and also with tin ores at Wodgina, in the Pilbara goldfield.

Diamonds and Precious Stones.—A few small diamonds have been obtained at Nullagine in the Pilbara goldfield. Beryls and emeralds have been got at Poonah, near Cue, and rubellite at Greenbushes and Phillips River.

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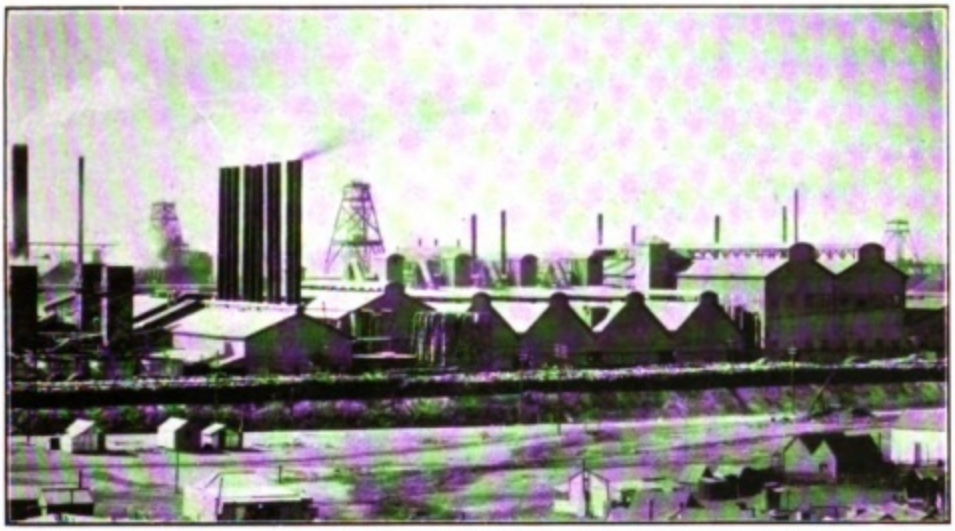
Phosphate Rock, Bauxite, Magnesite, Felspar, Kaolin, Talc, Clays, Building Stones and Limestones may also be mentioned as mineral products of the State likely to be of importance.

Iron Ores exist in Western Australia in very large quantities and of excellent smelting quality in several places, and less pure brown iron ore and laterite deposits are very common. At present conditions do not favour iron-smelting, but in good time doubtless the wealth of iron will be utilised.



IT IS ONE OF THE RICHEST SQUARE MILES OF MINERAL COUNTRY IN THE WORLD.

Coal.—The Collie Coalfield has already been mentioned. The coal is not a coking one and somewhat friable in furnaces, so is not suitable for blast furnace smelting. Its calorific value is somewhat low, being only from 9,000 to 11,500 British Thermal Units as a rule. The use of this coal for bunkering steamships has now become well established, its location on the West side of the Australian continent giving it advantages of position which to some extent compensate for its inferiority to the coals of New South Wales in calorific value. It has been found also to be particularly good fuel for use in suction gas-producers supplying gas to gas-engines, a use which is extending very rapidly.

ANOTHER SECTION OF THE GOLDEN MILE.

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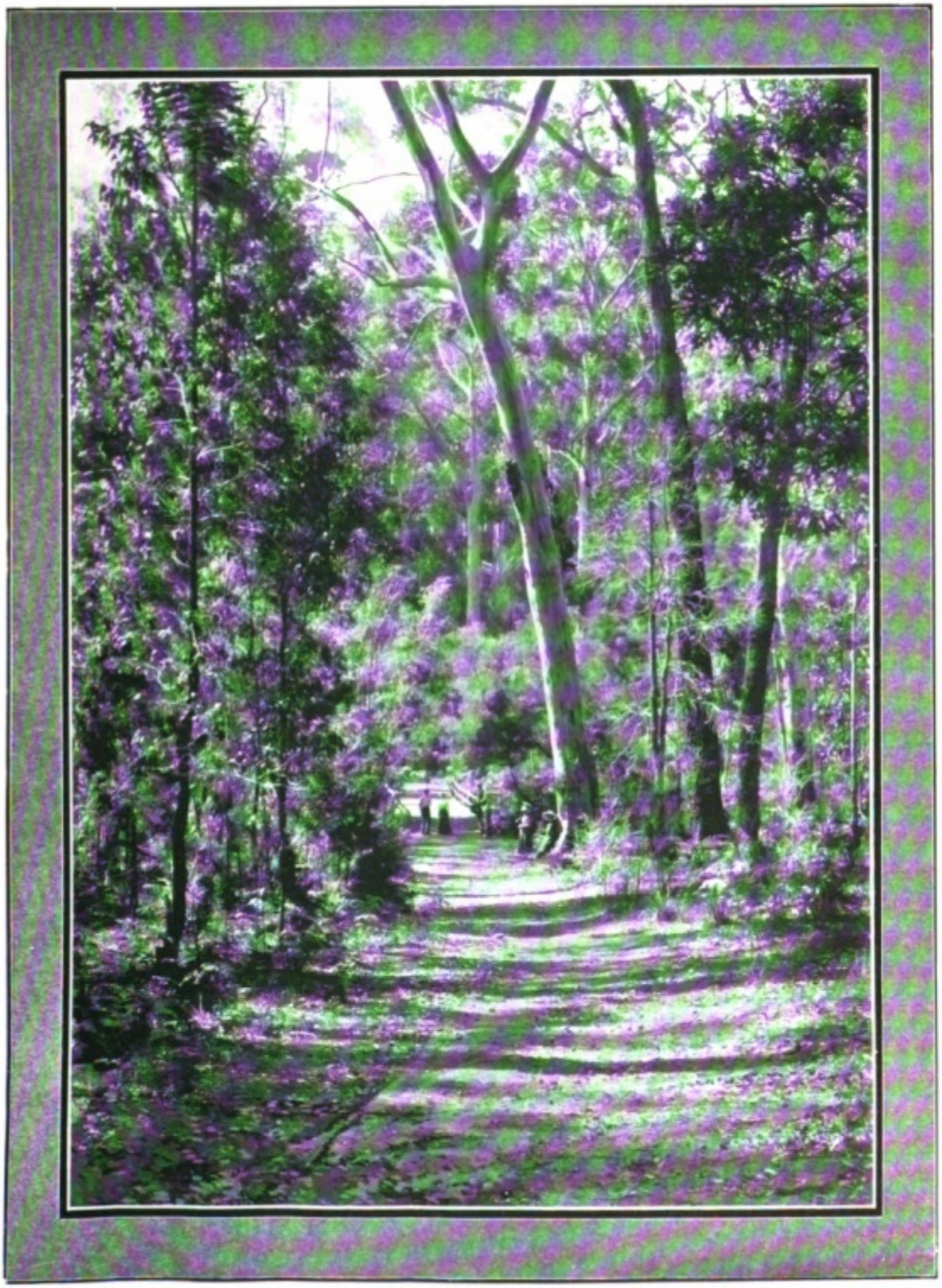

GLORIOUS DRIVES AND RIDES TO BE HAD THROUGH THE FORESTS OF THE SOUTH-WEST.

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The Geology of Western Australia.*

Introduction. Physiography. Systematic Geology. Economic Geology.

INTRODUCTION.

THE State of Western Australia is one, and the largest, of the tropical divisions of the Commonwealth, though it does not constitute a natural geographical region. It occupies, as its name implies, the Western portion of the Continent, and embraces an area of 975,920 square miles out of the 2,974,581 which make up the whole area of the Commonwealth. Western Australia lies between the 14th and 34th parallels of South latitude, though when viewed broadly it does not present any very great variety in its physical features.

Geological investigation in the State has, up to the present, consisted chiefly of a series of more or less unconnected observations, for the co-ordination of which we must look to the future. Despite this circumstance, it has now been found possible to obtain a bird's eye view of the salient geological features of Western Australia.

In the broad area of the State pretty nearly all geological systems have representatives in the rocks. In general the Pre-Cambrian rocks, which occupy about one-third of the superficial extent of the State, are found chiefly in the South-Western portion of the State, and in scattered areas North of latitude 26°. The Palæozoic systems are best known in the northern and the eastern interior, though they are also met with in the Irwin River valley to the north of Perth. The Mesozoic Rocks are exposed chiefly in the maritime districts of the State in the North-West, West and South. The Tertiary and recent

A STATE BATTERY.

*By A. Gibb Maitland, Government Geologist.

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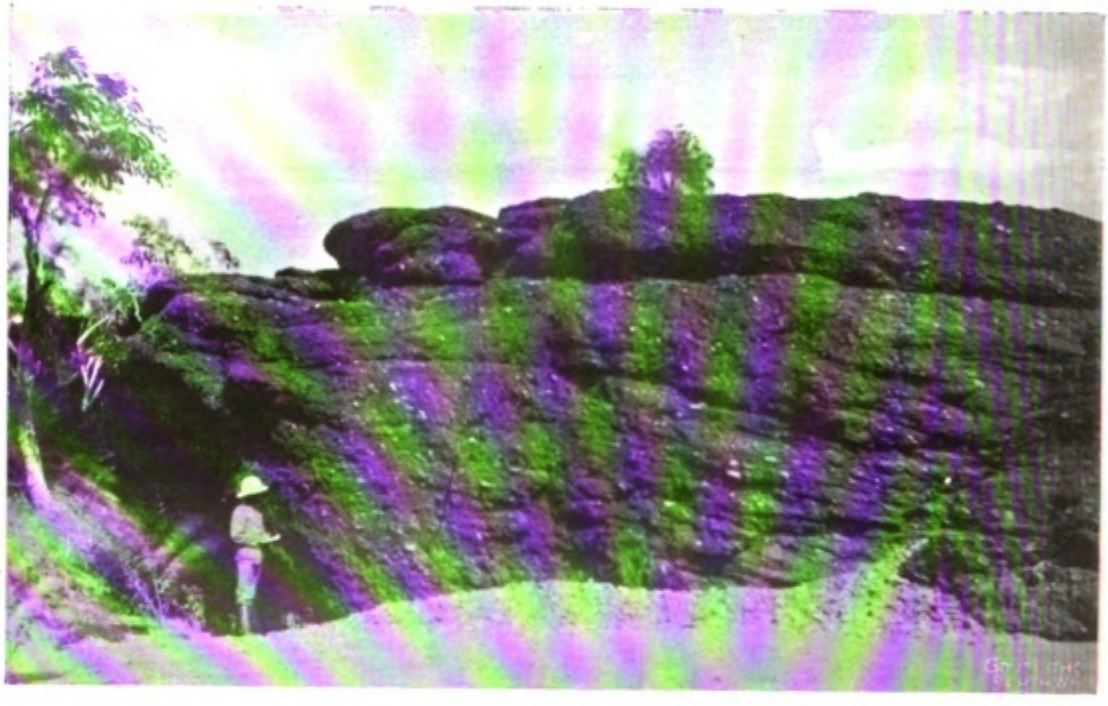
formations form a narrow fringe along the coast and have their widest distribution in the westernmost portion of the country.

Dr. F. von Sommer was the first official geologist employed in Western Australia, and held office from 1847 to 1857. Neither the maps nor the reports of Dr. von Sommer have ever been published, although some articles from his pen appeared in the current literature during the years 1848 and 1849. The



BASAL CONGLOMERATE (NULLAGINE SERIES), GOONANARRINA POOL, SHERLOCK RIVER.

original drawings of Dr. von Sommer's maps were discovered some years ago, and are preserved in the historical collection of the survey showing the progress of geological mapping in Western Australia, which is now on view in the Geological Gallery of the Museum.

After an interval of 21 years, during which much excellent geological work was accomplished by the Gregory Bros., Mr. H. Y. L. Brown was appointed to the post of Government Geologist. This gentleman during the years 1870 to 1873, prepared three geological maps and ten reports, dealing principally with the southern and maritime portions of the State. In 1882, Mr. E. T. Hardman, of the Geological Survey of Ireland, was appointed Government Geologist, and his labours were confined chiefly to the Kimberley Division, in which he was the pioneer geological observer; his field work, carried out during the years 1883-4, laid the foundations of our knowledge of the geology of the tropical portion of Western Australia, and played an important part in the opening up of the State's first goldfield. The late Rev. C. G. Nicolay, Chaplain to the Fremantle Gaol, contributed in very many ways to the knowledge of the geology of the State, and was officer-in-charge of the Geological Museum at Fremantle, which was founded

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by Mr. Hardman, and which ultimately became merged into the Western Australian Museum. In 1887 the position of Government Geologist was conferred upon Mr. H. P. Woodward, who held the position from 1887 to 1895. With a very limited staff, and still more limited appropriation, and in spite of the difficulties presented by the vast area of the State, the survey under Mr. Woodward issued 21 reports and six geological maps. It was during this period that the paramount necessity for "the publication of reliable geological knowledge relating to the nature and extent of useful mineral deposits, supplemented by geological maps and plans," was impressed upon the Government by its scientific advisers.

The work of organising a more or less systematic geological survey was entrusted to the writer in 1896, and had for its object the investigation of the geological structure, mineral and allied resources, and underground water supplies of the State.

PHYSIOGRAPHICAL FEATURES.

Physiographically considered the State of Western Australia falls naturally into three fairly well-marked subdivisions, viz. :—The Coastal Plain, the Hill Ranges, and the Plateau and Plains of the Interior. Each of these subdivisions is comparatively well-defined, though the line of separation cannot always be very sharply drawn, owing to the blending of one subdivision with another; hence the boundaries can only be spoken of as occurring within certain limits.

AN ARTESIAN BORE.

For purposes of description the State may also be divided into six geographical divisions, viz. :—The Northern or Kimberley, the North-West, the South-West, the South-East or Eucla, the Central or Salt Lake, and the Eastern Divisions. The boundaries of these divisions are fairly well marked.

The Coastal Plain consists in reality of a fringe round the coast with a more or less gentle slope to the seaward. The plain has a width of 60 or 70 miles in places on the Western Coast, though in the country at the head of the Great Australian Bight it extends some 200 miles into the interior, and is absolutely devoid of rivers. The inner margin of the Coastal Plain reaches an altitude of 600 feet above sea level in certain localities. The line of demarcation of the Coastal Plain, and the Hill Ranges on the East, is marked by what is termed the Darling Fault Scarp, averaging about 1,000 feet in height and traceable to the North and South of Perth for over 300 miles. The western limit of the coastal Plain is at the edge of the continental shelf, which is located a great many miles

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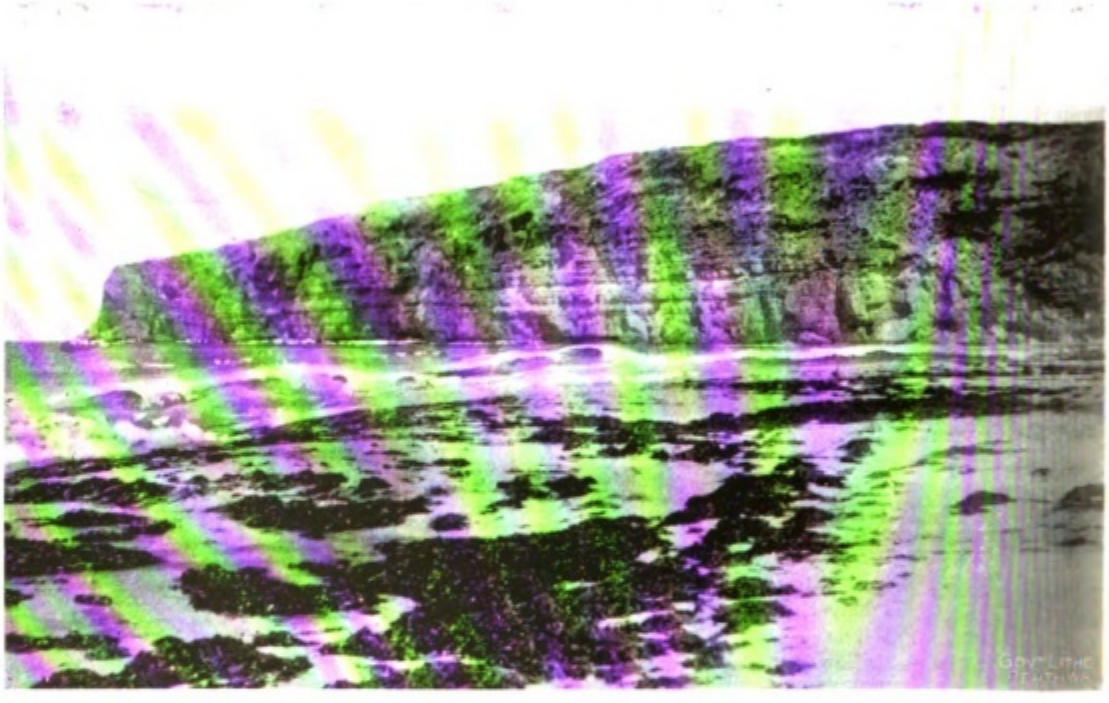
off the shore line at a depth of about 100 fathoms below the surface of the Indian Ocean. This is in reality the submerged border of the Western portion of the Australian Continent, which extends seawards with a gradual slope to the 100 fathom line.

The Coastal Plain may thus be divided into a submarine and a subaerial division, the line of demarcation between which is the sea shore. The subaerial division is itself separable into the Western and South-Western portion, the latter comprising the Eucla Limestone Plateau or the Premier Downs, traversed



LIMESTONE CLIFFS, NEAR TWILIGHT COVE, EYRE.

by the Transcontinental Railway, now in course of construction. The average altitude of the northern or inland margin of this plain is about 1,000 feet above sea level. The rainfall is very slight, except near the coast, and no rivers enter the sea, anywhere, for 400 miles west of Eucla, on the South Australian border.

By far the greater portion of the State is in reality a very extensive plateau averaging about 1,400 feet in height, though isolated portions reach altitudes approaching 4,000 feet. The interior portion of the plateau has a very restricted and limited rainfall and is drained by intermittent water courses, which debouch into shallow basins, generally known as "Salt" or "Dry" lakes. Wind erosion is the predominating agent in the formation of these salt and dry lakes, and also the greatest denuding agent which tends to keep the plateau level. The plateau which forms the chief mineral region of the State, is mantled by superficial deposits concealing the underlying rocks over very wide areas.

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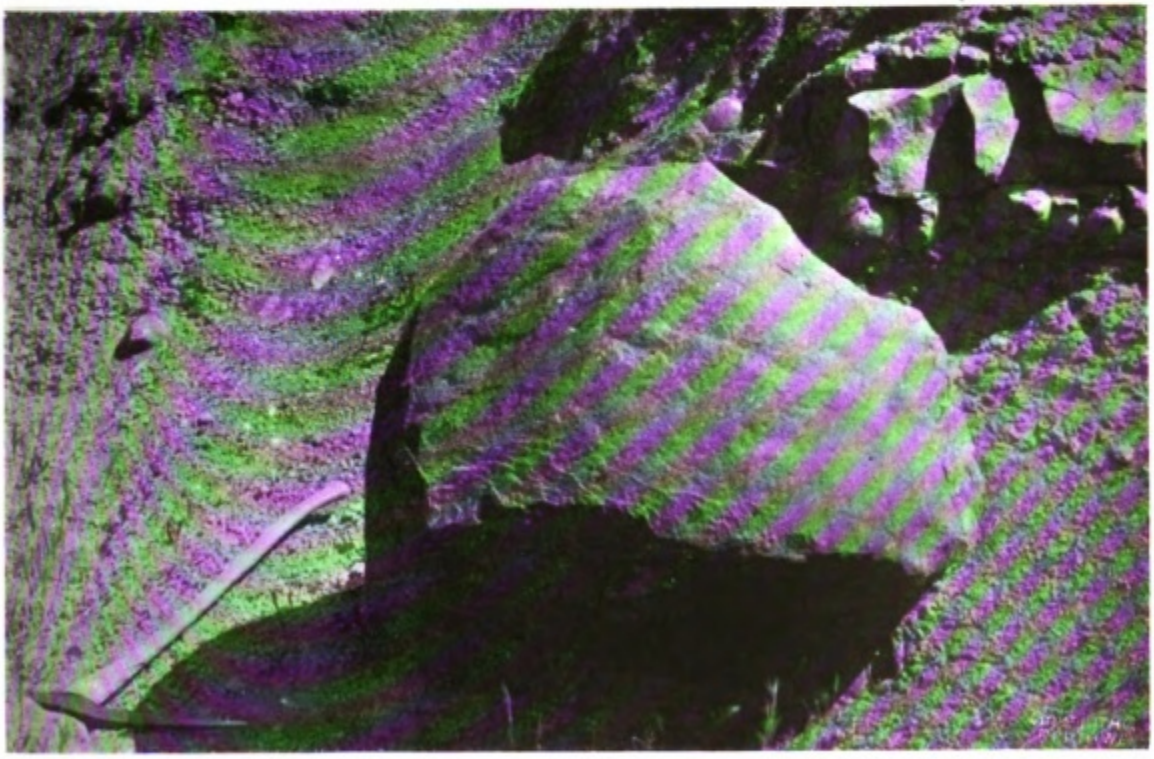
A large portion of the Kimberley and North-West Divisions consists of a dissected plateau built up of horizontal or gently inclined strata, and possesses in general all the familiar scenic features of such formations. This dissected plateau is drained by the principal rivers of the State, many of which extend for some hundreds of miles inland, and some of which flow through cañons of great extent and exceptional beauty.

There are no folded and little denuded mountain chains in Western Australia; such as do exist owe their origin either to block faulting or result from erosion.

The coast line is extensive and generally has a smooth irregular outline, though portions are broken and indented and fringed with numerous islands and archipelagoes. The very much indented coast line of the Kimberley Division is due to the drowning of the river valleys, of which the Prince Regent River, falling into Brunswick Bay, is the most typical example.

SYSTEMATIC GEOLOGY.

One of the most pronounced features in the geology of the State is the very marked diversity between the western and the eastern portion of the Australian Continent, and the very remarkable similarity in structure and constitution to that of India, South Africa, and Madagascar. This noteworthy resemblance is paralleled not only in the Pre-Cambrian Rocks, but also in the Palæozoic and Mesozoic Beds.



GLACIATED GRANITE BOULDER, EMBEDDED IN BLUE CLAY, IRWIN RIVER.

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PRE-CAMBRIAN, ARCHAEAN (?)

The oldest known rocks of Western Australia comprise a great group of crystalline rocks, which almost everywhere constitute the foundation of the State. There are huge tracts over which sedimentary strata effectually conceal the crystalline rocks. To the whole of these rocks, however, observers have invariably assigned an Archaean age; but this is rather inferred than proved. In the absence of any other evidence it has been found convenient to separate the crystalline rocks of the State into two great lithological groups, viz., (*a*) gneissic, granitoid, and schistose rocks, and (*b*) a group of conglomerates, quartzites, phyllites, schists

HANNAN STREET, KALGOORLIE.

and soft felspathic and micaceous gneiss, associated with basic rocks, which have been at times converted into greenstone schists. The rocks have been more or less irregularly folded along highly inclined axial planes; the folding is meridional, the prevalent strike being generally north-west and south-east.

Some of the hornblendic rocks may possibly represent original gritty beds made up of epidote, chlorite, etc., and the magnetic hematite quartz schists, referred to below, may perhaps have originally been ferruginous grits of sedimentary origin.

A remarkable and very noticeable feature of these older rocks are those bands of laminated cherts and jaspers, which often contain oxide of iron to such an extent as to warrant their being classed as iron-ores. These extend as roughly parallel bands, sometimes several miles in length, in the form of attenuated lenses, which, owing to their serrated ridges, stand out in bold relief, thus acquiring a conspicuousness out of all proportion to their real stratigraphical importance. These bands are often intersected by numerous faults, which in some districts are of considerable economic importance, for it is along these fault lines that rich shoots of gold often occur.

These older rocks are invaded by masses of veins of granite and allied rocks, which in many parts of the State occupy very large areas, sometimes embracing hundreds of square miles. The old granitic rocks are traversed by many large ice-like quartz reefs, which rise to considerable altitudes above the surface like

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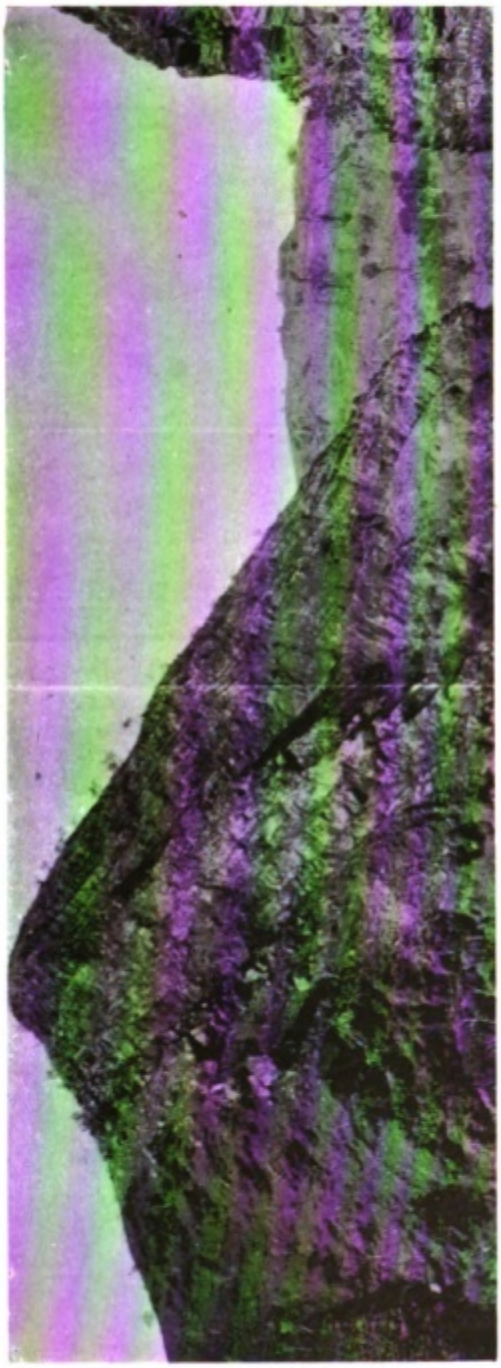
a wall, and which can in some cases be traced across country with more or less interruption for miles.

The mode of occurrence of these large quartz masses points to their being of igneous origin, representing the final product of the differentiation of a granitic magma—its ultra-acid portions.

There are probably few parts of the Australian continent which can boast of a finer development of these older rocks than Western Australia.

Nullagine Series.—Age undetermined. A formation which has been designated the Nullagine Series, and which cannot be exactly correlated with any defined geological horizon in Western Australia, has a very wide distribution in the North-West Division of the State. The series consist of a great thickness of sandstones, grits, conglomerates, and limestones, some of which are magnesian, together with a series of lavas, ashes, and agglomerates. (Fig. 3.) The formation is of some economic importance, by reason of the fact that the basal members of the series have proved to be auriferous in two localities, viz., Nullagine and Just-in-Time.



JUNCTION OF METAMORPHIC AND DEVONIAN ROCK, ELVIRE RIVER.

The beds of the Nullagine series make a very prominent feature in the landscape in the districts in which it is developed, and play a very important part in the geology of the North-West. The series may be followed from the Oakover River, across the upper reaches of the Nullagine, the Coongan, and the Shaw Rivers, as far as the western boundary of the Pilbara Goldfield on the Yule River, near Cangan Pool, from which locality it can be followed without a break to Roebourne, and southward to the Fortescue River. The same series constitutes the Hamersley Range, which contains Mount Bruce, the highest summit in the State.

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In its lithological characters and general behaviour the Nullagine Series bears a very strong resemblance to the quartzites, etc., which constitute that continuous formation which extends from Wyndham to Mount Hart, a prominent summit in the King Leopold Range in the Kimberley Division. This formation as developed in Kimberley consists of a series of quartzites, sandstones, fine conglomerates, and shales, disposed in a series of broad anticlinal folds. Associated with the

COOLGARDIE CELEBRATES THE OPENING OF THE RAILWAY IN 1896.

sediments is a series of bedded and intrusive igneous rocks, some of which are distinctly amygdaloidal, and contain zeolites and agates in the cavities. Beds of volcanic ash and breccia are common in certain localities. In certain portions of the King Leopold Plateau are many excellent sections showing the intrusive nature of some of the igneous rocks. The sandstones are sometimes altered into hard compact quartzite, portions of which have been caught up in the body of the igneous rock. Other sections indicate quite clearly that some of the igneous rocks have found an easy passage along the bedding planes of the sedimentary rocks, and evidently occur in the form of sills. The lavas are traversed by almost vertical dykes of epidosite, which are traceable across country for long distances; while both the sedimentary and igneous rocks are intersected by numerous segregation veins of quartz, some of which are of considerable size and horizontal extent.

The recognition of the position of the beds of the Nullagine Series in the stratigraphical succession is of considerable importance; the entire absence of fossils throughout the series renders correlation extremely difficult. The beds forming the King Leopold Plateau have been claimed by previous observers as being of Cambrian age. If the lithological and stratigraphical resemblance between beds of the King Leopold Plateau and those of the Nullagine Series, as developed in Pilbara and the Ashburton, should prove to possess greater significance than at present appears, a Cambrian age for the Nullagine Series would have strong claims to acceptance.

In its lithological characters and its structural relationships the Nullagine Series bears a very marked resemblance to that formation in South Africa known as the Potchefstroom or Transvaal System, which is Pre-Devonian in Age.

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Cambrian.—Strata of undoubted Cambrian age are known to occur in the Kimberley district, and were discovered by Mr. E. T. Hardman in 1883 4. In the course of his explorations this observer gathered a suite of fossils, amongst which were the head and spine of a trilobite belonging to the characteristic Cambrian family *Olenellus*, *O. Forresti*, and numerous Pteropods, *Salterella Hardmani*. These came from a locality which, unfortunately, cannot now be definitely identified. Despite the poor localisation of Mr. Hardman's fossils it may be considered as proved that Cambrian strata do occur somewhere in Kimberley about 18° southern latitude. The strata with which these fossils were associated consist of limestones, sandstones, quartzites, clay slates, and sandy flags. The superficial area, however, would seem to be extensive, for they have been proved to extend in a north-east and south-west direction from the Burt Range and for some distance to the southward of Mount Dockrell. The strata have been tilted in such a way that the principal axis of folding is north-west and south-east. No estimate has yet been made of the thickness of these, the oldest fossiliferous beds yet found in Western Australia. The discovery of *Olenellus* and *Salterella* in the limestones of the Daly River, in the Northern Territory, is of considerable geological importance, indicating as it does a somewhat wide distribution of Cambrian strata in the northern portion of Australia.

Silurian.—The occurrence of strata of Silurian Age in Western Australia has been rather inferred than proved. Certain rocks occurring in the Mount Barren Range were described in 1861 by Mr. F. J. Gregory as probably belonging to this period, though the evidence upon which this determination was based was not given.

The strata forming the Stirling Range, which lies about 30 miles to the northwards of Albany, have been claimed as Silurian. The Stirling Range Beds form a grand chain of mountains, which lie not very far from the coast, and form

GOLD! LOADING CAMELS FOR A NEW RUSH IN THE EARLY NINETIES.

one of the most conspicuous scenic features in the South-eastern portion of the State. The beds consist of quartzites, sandstones, and shales, the whole being traversed by quartz veins ; they are highly folded, contorted, and faulted in places.

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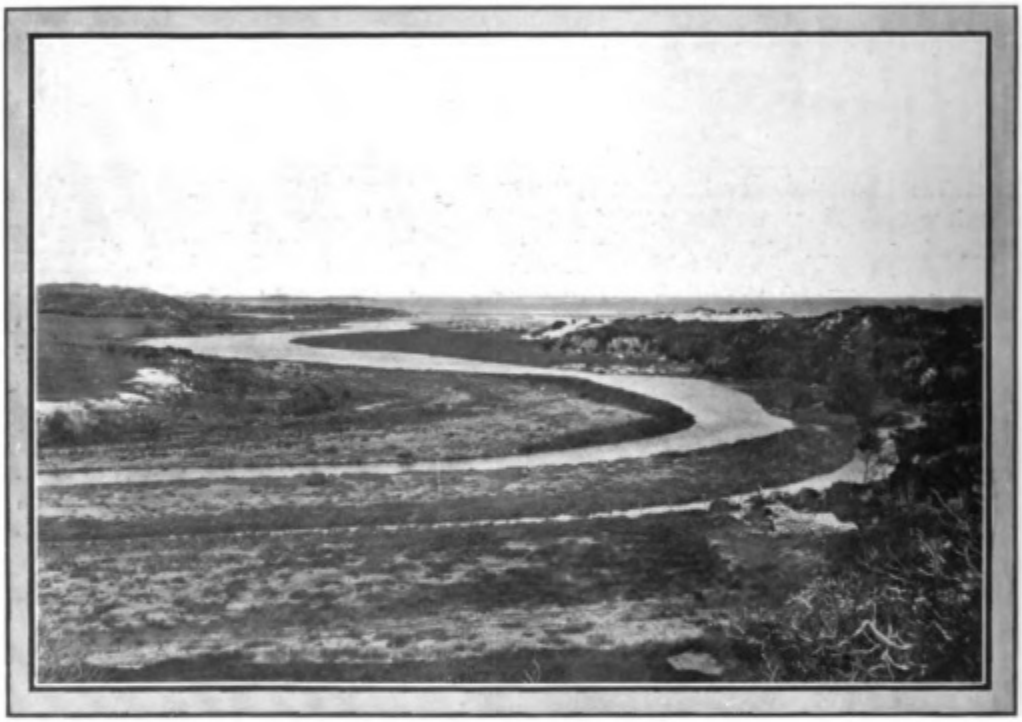
The rocks at the western end of the Range, near Moondinup, have been thrown into three sharp anticlinal and synclinal folds, in a distance north and south of about ten miles, by a lateral compression from the south. The Stirling Range Beds bear a very remarkable resemblance to the Table Mountain Sandstone Series as developed in South Africa, which have been claimed as Devonian.

The strata chiefly developed in the King Leopold and Mueller Ranges of Kimberley have been provisionally classed by Mr. E. T. Hardman as Silurian, more on account of their lithological character than on any stratigraphical or palæontological evidence. The beds consist of pure crystalline quartzites,



MOUTH OF THE IRWIN RIVER.

indurated grits, and quartzose conglomerates, interbedded with purple slates and soft sandstones. Much detailed field work is, however, required before the occurrence of undoubted Silurian rocks in Western Australia can be considered to have been definitely proved.

Devonian.—The occurrence of Devonian rocks has as yet been definitely proved only in one district of the State—the Kimberley Division, where this formation appears to be largely developed. The beds consist of hard grits, conglomerates, indurated limestones, and shales, associated with which are contemporaneous lava flows, breccias, and ashes. In the Napier Range the Devonian rocks are represented by solid crystalline limestones, with at the base of the formation a calcareous breccia and conglomerate. These beds are seen in the Barker River Gorge to pass beneath a series of sandstones and shales of what is believed to be Carboniferous age.

Among the fossils found in the Napier Range beds are a *Coccostean* fish, a new species of *Proetus*; remains of *Loxonema*, sp.; *Euomphalus*, sp.; *Rhynchonella*,

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allied to *R. Timorensis*; *Pachypora*, sp.; *Phillipsastraea*, sp.; and *Goniatites*, sp.; which clearly indicate a Devonian age for the strata.

The list of Devonian fossils of Western Australia will be found set out in Bulletin 50.

Permo-Carboniferous.—The Permo-Carboniferous rocks cover a wide extent of country, and there are four regions in which the beds are known, viz., Kimberley, Gascoyne, Irwin River, and the Collie River. Wherever these Permo-Carboniferous rocks have been examined in Western Australia it has been found that the formation can everywhere be divided into a lower or limestone series (in which limestones predominate), and an upper or sandstone series (made up largely of sandstones and other sedimentary beds).

Interbedded with the Permo-Carboniferous rocks of the North-West and the Irwin River is a very persistent boulder bed, the component pebbles of which are covered with striæ of such a nature a to suggest that they owe their origin to

SLUICING AT GREENBUSHES TINFIELD.

ice action. Sections occur which show that this bed does not attain any great thickness, and that it is crowded with pebbles and boulders of granite, etc., embedded in a calcareous, fossiliferous matrix, which contains fragments of *Spirifera*, *Productus*, and *Polyzoa*, in addition to *Aviculopecten tenuicollis*. The fossil contents indicate a marine origin for the boulder bed. As it is convenient to have a name by which to designate this important geological horizon, it is proposed to use for it the term "Lyons Conglomerate," which is the official designation of the land district in which it was first discovered, and where it is so well developed. Whenever seen *in situ* it has been found that this glacial boulder bed (the Lyons Conglomerate) does not lie quite at the base of the Permo-Carboniferous rocks as developed in Western Australia. The Lyons Conglomerate marks an important geological horizon, which has been proved to extend for a distance of about 200 miles.

There are sound geological reasons for believing the Lyons Conglomerate to have been contemporaneous in age with those beds which afford evidence of the glaciation that affected India, South Africa, South America, and Eastern Australia.

The Permo-Carboniferous rocks of Western Australia have yielded a rich assemblage of fossils, which will be found set out at length in Geological Survey Bulletin 50 (*q.v.*)

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The Western Australian Permo-Carboniferous fauna very closely resembles that of India.

According to recent researches into the palæontology of the Salt Range beds of India, it appears that *Spiriferina lata*, McCoy, of Western Australia, is hardly to be distinguished from *Spiriferina infer*, Waag, occurring in the Lower Productus Limestone. *Spirifera Hardmani* is merely a variety of *Spirifera Marcoui* occurring at Amb.; *Athyris Macleayana* is identical with *Athyris capillata*; *Aulosteges Baracoodensis* likewise can hardly be distinguished from *Aulosteges Medlicottianus*; *Productus tenuistriatus*, var. *Foordi*, Eth., from the group *Productus tumidus*. The fossils from the Irwin River beds also show an intimate relationship with those of the Productus Limestone of the Salt Range, viz.:—*Productus subquadratus* belongs to the series of *Productus Abichi*; *Productus undatus* is like *Productus opunta*, and *Productus tenuistriatus* resembles *Productus tumidus*.

Jurassic.—The Jurassic rocks of the State have a fairly wide extent, especially in the Champion Bay district, near Geraldton. Rocks of this age have also been recorded from Sharks Bay and also from Cape Riche to the east of Albany. From this latter locality *Ammonites* (*Perisphinctes*) *Championensis*, sp. nov., has been recorded, but there is some doubt as to whether or not this specimen has been correctly localised, or that it really came from Champion Bay. The Champion Bay beds cover a fairly large area of country to the south, in the neighbourhood of the coast line. They are seen to rest with a marked unconformity on the Carboniferous rocks of the Irwin River valley. They also extend northward,

LAKE WAY, EAST MURCHISON GOLDFIELD.

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FRESHWATER BAY. A SUBURBAN VIEW OF THE SWAN RIVER.

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having been met with at Sharks Bay and on the Gascoyne River, near the Kennedy Range. The Jurassic beds of the State are represented by oolitic limestones, clays, sandstones (which are often ferruginous), grits, conglomerates, and lignites. Some of the ferruginous sandstones contain abundant plant remains. As a rule the strata are horizontal or but gently undulating, and have probably been deposited along the then coast during a long period of depression. No estimate can as yet be made of the thickness of the Jurassic beds ; they have, however, been pierced by four bore-holes in the Champion Bay district, which have proved the thickness to be not less than 2,000ft. The plant remains occurring in these beds near Mingenew seem to indicate that the beds are the equivalents of those at Talgai and Rosewood, in Queensland.

These Jurassic beds are of considerable economic importance, from the point of view of the occurrence of artesian water, and several abortive efforts have been made to reach them by means of deep bores beneath the ucretaceous rocks of the Metropolitan Area. The importance of these Jurassic rocks from the hydro-geological standpoint is their general permeability, which lends itself to the absorption and transmission of large quantities of water, whilst the thickness of the formation gives it a very large storage capacity.

A RIVER IN THE TROPICS. GEIKE GORGE, 200 MILES UP THE FITZROY.

A complete list of the Jurassic fossils will be found in Bulletin 50.

Cretaceous.—The presence of Cretaceous strata in Western Australia appears to have been known for pretty well half a century, having been first recorded by Mr. F. T. Gregory as occurring near Gingin. This same observer stated that the Cretaceous strata were the most extensively developed of the sedimentary rocks of Western Australia, and that the beds were very closely connected with the Jurassic rocks of the Greenough River. The boundary between the two series, however, has not as yet been satisfactorily traced.

Fossiliferous Cretaceous rocks have been proved in three districts, viz., Eucla, the Metropolitan Area, and Gingin, and there are good grounds for believing that beds for this age occur in the valleys of the Gascoyne, Lyndon, and the Minilya Rivers.

The results of the recent boring in that enormous limestone plateau which extends from the South Australian border to the neighbourhood of Israelite Bay has proved the occurrence of Cretaceous strata lying beneath the Eucla limestone, which is supposed to be of Eocene Age. In bore No. 3, put down at the 337 miles 61 chains peg on the surveyed route of the Western Union Railway, at an altitude

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of 576ft. above sea-level, the following strata were passed through :—Eucla limestone, 603ft.; shales (sometimes glauconitic), 667ft.; fine and coarse sandstone and conglomerate, 74ft. ; and granite, 28ft. ; the total depth of the bore being 1,372ft. The beds beneath the limestone have yielded two of the most characteristic fossils found in the Lower Cretaceous strata of South Australia and Queensland, viz., *Aucella Hughendensis*, Eth. ; and *MacCoyella Corbiensis*, Moore, together with portions of a bivalve shell, possibly *Fissilunula*, which is found in the Lower Cretaceous beds of Eastern Australia. There is, therefore, little doubt that the strata pierced in No. 3 bore are the equivalents of the Rolling Downs Beds of Queensland.

The Cretaceous rocks of Gingin consist of white chalky limestone without flints, which passes downwards into a greenish glauconite marl, and below that into a clay shale. Above the limestone is a bed of very ferruginous sandstone, the whole series dipping to the northward at an angle of 8° to 9°.

LAVA FLOW, BUNBURY.

The Gingin beds have yielded an extensive series of fossils, and although the number of species which can be identified is comparatively small, nevertheless it contains much that is important and indicates that a large and important fauna could be obtained. Amongst the fossils (which will be found described in Geological Survey Bulletin 55) are new species of *Peronella*, *Coelosmilia*, and *Pollicipes*, in addition to seven new species of *Brachiopods* and a new Gastropod. An important feature is the appearance in the Gingin beds of types new to the Australian Cretaceous rocks, though common in the beds of the old world, the Australian facies, however, being maintained by the presence of *Inoceramus* and *Ammonites*.

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A purely homotaxial, though not a synchronal relationship, has already been shown to exist between the Cretaceous rocks of Australia and Europe, whilst as a result of recent palaeontological research into the rocks of Western Australia, it now appears that a much nearer connection probably exists with the Cretaceous rocks of India, thus affording another instance of that close geological kinship existing between the countries bordering the Indian Ocean.

FRESHWATER BAY, ON THE PICTURESQUE SWAN RIVER.

Further northwards, in the neighbourhood of Dandarragan, is a white chalky limestone, at the base of which lies a phosphatised bone bed, associated with sandstones and shales, which are occasionally glauconitic; these beds, which contain *Ostrea* and *Inoceramus*, are of the same geological age as the Gingin strata, with which they appear to be coterminous.

According to such geological field evidence as is at present available, the Cretaceous and Jurassic beds of the Coastal Plain owe their present position to faults, which trend generally north and south.

Tertiary.—Owing to the absence of valuable mineral deposits the Tertiary strata have not as yet received much attention at the hands of the Survey.

The basal beds of what are believed to be Tertiary strata are seen to rest unconformably on the eroded surface of the Jurassic beds of the Champion Bay district. The beds consist of limestones, sandy shales, and sandstones, which form a relatively narrow strip of country along the coastline.

Similar strata occur at Sharks Bay and to the southward of Perth, extending as far as the South Australian border, where the chalky limestone that bulks largely in the formation contains fossils which seem to point to its being of the Eocene age.

In the South-Western portion of the State the Tertiary strata are associated with basaltic lavas as well as basaltic dykes. These basaltic lavas may be seen at Bunbury, at several places in the Blackwood River, at Black Point on the south coast, and near Silver Mount between the Warren and Donnelly Rivers. They were also cut in two of the bores put down in the search for petroleum on the Warren River.

In the Kimberley Division basic lavas and ashes occur in great force. These Tertiary lavas and ashes appear in the valleys of the Ord and the Bow Rivers to

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have levelled up the depressions formed therein, except certain knife-edged ridges of the older rocks which still protrude above the general level. On the Behn River, just above what is known as the Gorge, a dome or puy of basalt, which apparently formed one of the foci from which some of these lavas issued, has been described.

At Norseman remnants of an extensive dolomitic limestone formation at an altitude of 900ft. above sea-level and 100 miles distant from the coast have been discovered. This bed at Norseman contains species of *Turitella*, allied to *T. terebra*, *Pecten*, *Cardium* (or *Cardita*), *Magellania*, and fragments of *Polyzoa*.

OUTCROP OF LAMINATED QUARTZITE, MT. HUNT, EAST COOLGARDIE GOLDFIELD.

Laterite.—No account of the geology of Western Australia would be complete without some reference to that extensive development of residual deposits which occur in nearly all portions of the State, and for which the term laterite has been adopted. The laterites consist largely of hydrated oxide of iron and alumina, producing on the one hand deposits of iron ore, and on the other bauxite. In some localities the deposition of secondary silica in the laterite deposits produces what are practically quartzites. These, by an increase in the ferruginous colouring matter, pass into a jasperoid form of laterite. There are thus three forms of laterite: an aluminous, a ferruginous, and a siliceous, the composition being liable to vary considerably over a small area, it being governed largely by the nature of the underlying rocks. The laterites pass gradually into the underlying rocks without any sharp line of demarcation. The ferruginous and siliceous laterites are much commoner than the aluminous variety. This arises from the fact that the former types are better able to resist disintegrating

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influences ; they thus not only remain themselves, but act as a protecting cover for the rocks beneath. The lateritic deposits occur as disconnected outliers which once formed part of a continuous deposit. It is difficult to escape the conviction that the laterites are of some geological antiquity, of which possibly the thickness and state of consolidation may be some measure. On such geological evidence as is available the laterites seem to be of earlier age than Late Tertiary, though there is but little doubt that similar deposits are forming at the present time in the State.

ECONOMIC GEOLOGY.

The principal mineral products of greatest importance in Western Australia, arranged in order of value, are gold, copper, coal, tin, lead, and phosphates. The metals and metalliferous minerals make up by far the greater proportion of the value of the output, being over 98 per cent. of the total.

Over 54 per cent. of the total gold output of the State has been obtained from the East Coolgardie Goldfields, which contains the important mining centre of Kalgoorlie.

The mineral deposits of the State occur in areas generally as more or less parallel belts of relatively narrow lateral dimensions, though in certain localities they appear as small isolated areas or patches. These narrow well-defined belts have a general north-west and south-east direction, with occasional divergences of several degrees on either side. The ore deposits in these zones or belts, owing to dynamo-metamorphic processes, do not crop out in long lines, but are cut up into relatively short lenticles, arranged *en echelon*.

A POOL IN THE KIMBERLEY COUNTRY.

In addition to the minerals alluded to above, the State possesses a possible asset of very great value in the deposits of laterite which occupy such extensive areas in many localities. Some of the deposits contain considerable quantities of alumina, and are in every respect identical with bauxite, which mineral is now the chief source of aluminium.

Full details as to the geology of the mineral deposits will be found in Geological Survey Bulletin 50, and Chapter X. (The Mining Fields of Australia) of the Volume issued by the Commonwealth Government, and need not be repeated.

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AN UPPER REACH OF THE SWAN RIVER.

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JARRAH FOREST; THE USE OF THIS HARDWOOD IS WORLD-WIDE.

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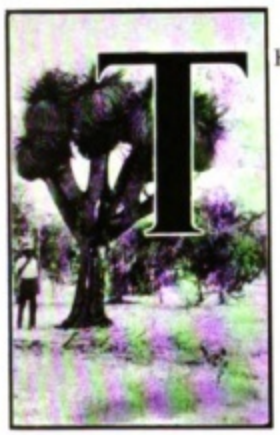
The Flora of Extra-Tropical Western Australia.

Phanerogams and Vascular Cryptogams.*



THE particularly interesting nature of the Flora of Western Australia was recognised by European botanists throughout the nineteenth century. A few specimens, still preserved at Oxford, had been brought to England by Dampier about the year 1700. Nearly a hundred years later Menzies, who had been appointed on Banks's recommendation as surgeon and botanist to Vancouver's expedition, brought back a collection from King George's Sound, as the result of a fortnight's stay there. But the first really comprehensive study of our Flora was that which Robert Brown carried out in 1802–5. He had been appointed by Sir Joseph Banks as naturalist to Flinders' voyage of discovery, and his *Prodromus Florae Novae Hollandiae* was the foundation of Australian systematic botany. The interest that was aroused by his work led to the demand for collections of plants from Western Australia. Amongst those who met the demand most successfully during the next sixty years were Baxter, von Huegel, Drummond, and Preiss; while amongst European workers at the Flora the names of Lehmann, Lindley, and Bentham are conspicuous. During the latter half of the nineteenth century Baron Ferdinand von Müeller, by his collections and publications, added very largely to what was previously known of the vegetation of this State.

Though the South-Western portion of the State enjoys a good rainfall (about 34 inches annually at Perth, and considerably more in other parts), there are five consecutive months—November to March—in which the temperature is high and very little rain falls. Consequently the vegetation is typically xerophilous, and exhibits all kinds of devices for reducing transpiration. In an immense number of plants the leaves are small and narrow-linear in form, or reduced to mere spines: in many they are suppressed altogether or appear as minute scales. The leaves of many other plants, especially in the interior, where the rainfall is much less, are protected by woolly coverings or by coats of sticky varnish; others assume a fleshy form; others contain quantities of essential oils. The larger leaves are generally hard and leathery. Phyllodes and flattened stems are common in cases where the true leaves are suppressed.

The trees and shrubs are invariably evergreen. The large forest trees are all *Eucalypti*, of which some sixty species are found here. Many of these furnish timber of great value. The Jarrah (*E. marginata*) in particular forms a very

* By C. Andrews, Esq., M.A.

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important article of export, being in great demand for railway sleepers and street paving in many parts of the world. The principal species round Perth are the Jarrah, the Red Gum, (*E. calophylla*), the Tuart (*E. gomphocephala*) and the White Gum or Wandoo (*E. redunca*). In the extreme South-West are found, amongst other species, the Karri (*E. diversicolor*), which sometimes exceeds 300 feet in height, and the Scarlet-flowering gum (*E. ficifolia*), which is frequently planted in parks and gardens on account of its brilliant masses of red blossom.

Among smaller trees are other *Myrtaceæ*, belonging to the genera *Melaleuca* ("Paper-barks" or "Tea-trees"), and *Agonis* (including the "Peppermint"). *Leguminosae*, of the genus *Acacia* (Wattles), and *Proteaceae*, of the genera *Banksia* and *Persoonia*. All these are well represented in the neighbourhood of Perth. One conifer, a *Callitris* or Cypress-pine, flourishes on the banks of the Swan, and arborescent representatives of the *Santalaceae* may be found at no great distance. An interesting genus, which is common near Perth and over most of the South-West, is *Casuarina*, in which the leafless branchlets bear a curious resemblance to the stems of *Equisetum*; the trees are generally known as "Shea-oaks." Another tree of great interest in the same district is the endemic *Nuytsia floribunda*; it shares with a shrub found in the Blue Mountains the distinction of being the only non-parasitic member of the *Loranthaceae*. It is locally known as the "Christmas Tree," its brilliant orange flowers appearing in midsummer.

BANKSIA PRIONOTES.

Conspicuous features in the landscape in many parts of the South-West are the "Grass-trees" or "Blackboys," belonging to the genera *Xanthorrhaea* and *Kingia*, and variously assigned to the *Liliaceae* or *Juncaceae*. The caudex is often nearly a foot in diameter and sometimes 12–15 feet high; six to eight feet is a common size. The leaves of *Xanthorrhaea Preissii* are often four feet long, and its scape frequently measures six feet, being covered with flowers for more than half its length. Commonly associated with the Blackboy is a graceful Cycad, *Macrozamia Fraseri*, with palm-like leaves four or five feet in length.

The Flora of extra-tropical Western Australia is a very rich one in point of numbers. Nearly four thousand species have been described, and it is certain that there are still many plants that have escaped the notice of botanists. There is no doubt, too, that if our Flora were studied with anything like the minute care that has been bestowed upon such a Flora as that of the British Isles, the number of recorded species would be very greatly increased by the establishment of distinctions between plants that are at present included under one specific name.

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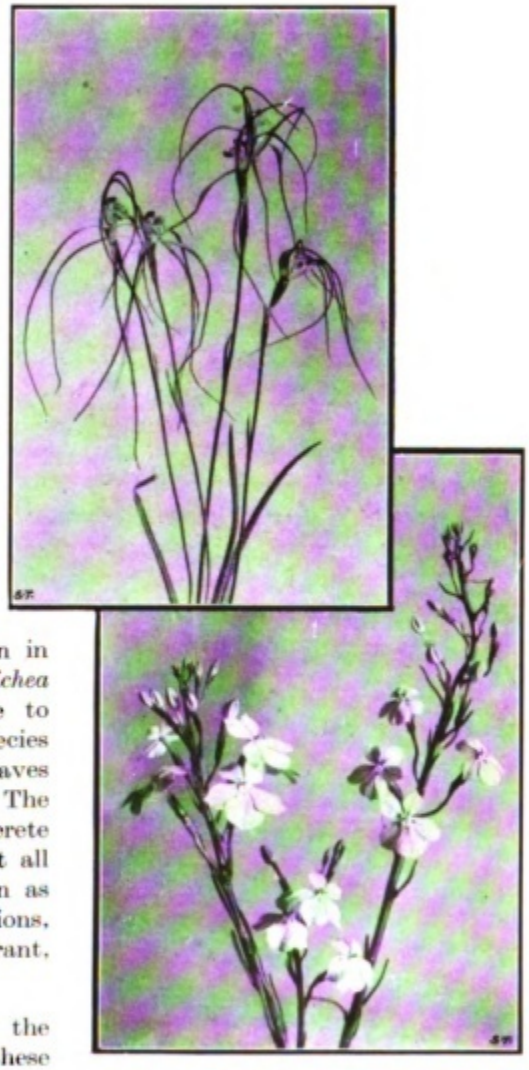
Of the 4,000 species, about two-thirds are endemic. The proportion of endemic species is especially remarkable in the South-Western districts, where the rainfall is considerable. This portion of the continent has been cut off from other regions where climatic conditions are approximately similar for an immensely long period, and the evolution of its plant-forms has naturally been very distinct. The desert belt which cuts it off is continuous with similar desert districts belonging to the other States, and its Flora naturally presents a greater likeness to theirs.

There are three orders which far surpass all others in point of numbers, viz., the *Leguminosae*, the *Myrtaceae*, and the *Proteaceae*. Each of these orders possesses over 400 species in extra-tropical Western Australia; the *Leguminosae* number nearly 500. All of them are conspicuous over the whole area. The *Leguminosae* have very few herbaceous representatives. All the three sub-orders are included. The *Papilionaceae* are very abundant—yellows, reds, and browns being the prevailing colours. The beautiful dark blue *Hoveas* are conspicuous about Perth in the winter and early spring, while *Templetonia retusa*, with its bright red flowers one and a-half inches in length, is a striking ornament of the limestone coast. Several genera contain plants that are very poisonous to sheep. The *Caesalpineae* are far less abundant: several species of *Cassia* are fairly common in the drier regions, and two species of *Labichea* are plentiful in the Darling Range, close to Perth. The *Mimoseae* include about 150 species of *Acacia*, of which only nine retain true leaves when developed beyond the seedling stage. The remainder exhibit various forms of flat or terete phyllodia, or, in a few cases have nothing at all resembling leaves. Many species are known as "Wattles;" many others, in the desert regions, as "Mulga." The bright flowers, often fragrant, are very conspicuous in the spring.



1. CALADENIA TENTACULATA.
2. ISOTOMA BROWNII.

Allusion has already been made to the arborescent *Myrtaceae*. In addition to these there are great numbers of "Heath-myrtles," small shrubs with very attractive flowers, amongst which those of the genus *Verticordia* are especially striking. Another large and conspicuous group depends for the brilliancy of its flowers upon its stamens, united in bundles and often of vivid scarlet or crimson colouring. Many of these are known as "Bottle-brushes." The fleshy-fruited genera of *Myrtaceae* are not represented here. All our species belong to the capsular group, which is almost confined to Australasia.

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The *Proteaceae* have their head-quarters in Western Australia. One of their sub-orders, the *Nucamentaceae*, appears in South Africa; the other, the *Folliculares*, is found in South America and Asia. Australia alone exhibits both. The other States of Australia possess between them about 200 species. Western Australia has more than 400, and of these only nine at the most are not endemic. Several interesting genera are confined to Western Australia, one of them, *Dryandra* possessing nearly 50 species. The large genera *Grevillea* and *Hakea*, as well as many others, are plentifully represented in the neighbourhood of Perth.

EUCALYPTUS CALOPHYLLA.

There are three other dicotyledonous orders with more than 100 species apiece, the *Compositae*, the *Epacridaceae*, and the *Goodeniaceae*.

The *Compositae* number about 250. Many of them are minute plants with inconspicuous flowers Many others are "everlastings." Only two of the forty-nine genera are represented in the British Flora—*Gnaphalium* and *Senecio*. The genus *Olearia* is very closely allied to *Aster*, and is fairly abundant. The principal genera of everlastings are *Helipterum* and *Helichrysum*, both of which are well represented in South Africa, though none of the species are common to both continents.

DAVIESIA HORRIDA.

Western Australia has no *Ericaceae*, but the closely allied *Epacridaceae*, or Australian Heaths, are represented by some 160 species, of which about half belong to the genus *Leucopogon*. Many of them flower early, and are abundant in the neighbourhood of Perth. The genus *Epacris*, which is found in all the other States, is absent from Western Australia.

The *Goodeniaceae* are almost exclusively Australian, and about 120 of the 200 Australian species are found in Western Australia. The genus *Leschenaultia* furnishes two of our most beautiful and conspicuous flowers, *L. formosa* varying from scarlet to crimson and orange, and *L. biloba* showing many shades of exquisite blue. The large genera *Scaevola* and *Dampiera* are among the most abundant of our blue flowers.

Two other dicotyledonous orders of special interest are the *Stylidieae* and the *Droseraceae*, both of which have their head-quarters in Western Australia.

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Of the former we have about 70 species, the only other representatives of the order being some 15 species confined to Eastern Australia, and two species in Asia. They are known as "Trigger-plants," from the elastic spring of their peculiar columns. In the early stages the ripe anthers occupy the top of the column. Later, when the pollen is shed, the stigma appears between the anthers. The delicate flowers are of great beauty and of great variety in colour; they are abundant all over the South-West.

Western Australia possesses more than half the known species of *Drosera*. The flowers show a great variety of colour—yellow, white, pink, scarlet, crimson, and purple. The plants vary from minute forms with rosettes of leaves scarcely more than an inch in diameter, and with flower-scapes little more than an inch in length, to sturdy, erect, much-branched plants a yard in height, or to climbers reaching a length of five feet. Though most of them prefer moist or swampy ground, some species grow regularly on bare, hot, dry sand, and others on rocky or gravelly hillsides. Besides *Drosera*, the anomalous genus *Byblis* is included in the order. *B. gigantea* is common on swampy ground near Perth, its flowers being conspicuous in early summer. When not flowering the plants are easily overlooked, except when the sun is low and lights up the dewy exudation that covers the linear leaves thickly throughout their length.

Other dicotyledonous Orders that are well represented are *Dilleniaceae*, of which the yellow flowered shrubs belonging to the genera *Hibbertia* and *Candollea* are very abundant; *Rutaceae*, including a few species of *Boronia* that are famed

EVERLASTINGS THROW A MANTLE OVER THE COUNTRY FOR MILES AT A STRETCH.

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for their delicious fragrance; *Sterculiaceae*, including a tree, the "Kurrajong," that grows in the arid interior; *Umbelliferae*, mostly small plants with simple umbels, the largest genus being *Hydrocotyle*; *Chenopodiaceae*, especially abundant in the interior, where some species, known as "salt bushes," afford valuable fodder; *Amarantaceae*, consisting chiefly of species of *Trichinium*, with scarious "ever-lasting" perianths; *Myoporineae*, to which belong the many species of *Eremophila* or "Desert-pride" that are among the most striking ornaments of the dry districts of the interior; *Verbenaceae*, with many desert forms showing flowers as well as leaves wrapped in coatings of dense wool; *Labiatae*, principally belonging to the peculiarly Australian tribe of *Prostanthereae*; and *Euphorbiaceae*, including species of *Ricinocarpus* with handsome large-petalled white flowers. The *Saxifragaceae* are represented by only three species, belonging to three different genera. One of these, *Cephalotus follicularis*, is of particular interest, owing to the conversion of many of the leaves of its radical rosette into "pitchers." This plant is abundant in swamps in the neighbourhood of Albany.

BORONIA MEGASTIGMA.

Among the higher Monocotyledons, *Orchidaceae*, *Liliaceae*, and *Haemodoraceae* are numerous, while the *Irideae*, though comparatively few in species, are very conspicuous through the abundance of the large purple and yellow blossoms of *Patersonia*, and the sky-blue flowers of *Orthrosanthus*.

THELYMITRA VARIEGATA.

The Orchids number more than eighty. All are terrestrial herbs, and all, with a single exception, belong to the tribe *Neottieae*. This group of *Neottieae* is essentially Australian, extending only to New Zealand, and, in a very few instances, to the Indian Archipelago. The most conspicuous genera are *Thelymitra*, with racemes of handsome regular blue or yellow flowers (with no distinct labellum), *Diuris*, and *Caladenia*. To the latter belong the Spider Orchids, of which the sepals and petals sometimes reach a length of five inches.

The *Liliaceae* are plentiful and varied. There are some striking and beautiful blue flowers of the genera *Agrostocrinum* and *Stypandra*, and many small white flowers that become conspicuous through their abundance.

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CALADENIA LONGICAUDA.

The largest genus is *Thysanotus*, with beautiful fringed lilac flowers generally known as "Fringe Lilies."

The Australian *Haemodoraceae* comprise seven genera, of which all except *Haemodorum* are confined to Western Australia. Far the largest genus is *Conostylis*, but the most curious and interesting plants belong to the genera *Blancoa*, *Anigozanthos*, and *Macropodia*. The large and brilliantly coloured flowers of *Anigozanthos*, with their flannelly texture and peculiar shape, are generally known as Kangaroo-Paws, and are among the most striking in appearance of all our Flora.

Among the *Glumiflorae* three orders are well represented—the *Restiaceae*, *Cyperaceae* and *Gramineae*.

The *Restiaceae* are almost confined to Australasia and South Africa, but only two genera, and no species, are common to both continents. There are over 60 species in Western Australia. Their determination is often rendered difficult by the great difference in appearance between the males and females of a species.

The *Cyperaceae* number more than 120, far the largest genus being *Schoenus*, with about 45 species. *Cyperus*, *Scirpus*, *Lepidosperma*, and *Cladium* are all fairly well represented, but there are only five species of *Carex*.

The *Gramineae* also number about 120. Perhaps the most conspicuous genus is *Stipa*. Two species of *Spinifex*, with their dense globular heads of spikelets, are very prominent on the sandy coast. The term "Spinifex" is never applied to these locally, but always to *Triodia irritans*, which is a characteristic plant of the sandy deserts of the interior.

The Vascular Cryptogams are poorly represented. There are only nine species of the *Lycopodiales*, and most of them appear to be very local. A species of *Marsilea*, known as Nardoo, affords food to the aborigines in the interior.

HEMIANORA PUNGENS.

The scarcity of ferns is remarkable, as many of the valleys in the well-watered hills of the South-West appear to be admirably suited for their growth. Only

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16 species are known to occur, and some of these are local and rare. Not one is endemic; in fact all have a wide distribution outside Australia. The two that are most abundant are the common Bracken and *Cheilanthes tenuifolia*.

Cycadaceae.*

To the English visitor, one of the most striking features of the vegetation in Western Australia is the number of Zamia "Palms" that are seen dotted about, sometimes within a few yards of each other. The quaint "Black-boys" or grass trees and these Cycads alter the aspect of the vegetation so much, that they give quite a character to the landscape where they occur.

THE HANDSOME BLACKBUTT.

The name of this common Cycad is *Macrozamia fraseri* Miq., and it is the most important, perhaps the only, example of the Cycads found in Western Australia. Systematically, the species is not sharply marked off. It is closely related to the Eastern species *Macrozamia spiralis* Miq., and the Central Australian species *Macrozamia macdonelli*, F. von M. In fact all three appear to be modifications of a single type which stretches across Australia between Lat. 25° and 30° South. The Western Australian species seems to be more strongly built in every way than its Eastern relations. The only one which appears larger is *M. perowskiana*, Miq., of tropical Queensland.

In *Macrozamia fraseri* the stiff pinnate leaves crown the top of the stem; in the middle of this funnel of leaves stand the cones. Usually there are several cones present, the female cones being the larger, reaching a length of about 18 inches. In many regions it is rather rare to find the fruits at all. It has been stated that Macrozamia fruits more richly in the hilly regions of the edge of the Central Plateau, and this has been considered to indicate that its original home was probably at the height of 900 feet or more. This statement, however, is not altogether correct, and I have found places on the banks of the Swan River, near Fremantle, where a large number of Macrozamias were all bearing fruit in great profusion. Furthermore, at the present time *M. fraseri* is not confined to the

* By Mrs. C. M. G. Dakin, B.Sc.

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THE FLOWER SPANGLED SLOPES OF THE DARLING RANGES.

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South-West hilly region, but is found North and East far beyond the wood region. The plants are to be found growing on soft sand, on the conglomerate of the plateau, and also on clays. Their present distribution within the area in which they occur, shows many irregularities. Over wide areas the species is rare, whilst in other places it is common, large numbers growing in quite a small area. The conditions determining this are not yet known.

MARINE ALGAE.*

Sixty years ago, William Henry Harvey, M.D., F.R.S., Professor of Botany in the University of Dublin, visited the shores of Australia to make collections of marine Algæ. The number of species of Algæ dispersed along the Australian coasts was estimated by him at nearly 1,000 ; the number actually known then being about 800.

Since that time the Algæ on the Eastern and Southern coasts have been further investigated, and many new species found, but the Algæ of Western Australia have apparently remained almost unrecorded since the work of Harvey. Even his collections did not extend further North than Fremantle, so that more than half the coast remains to be explored. Collecting sea-weeds off the coast of Western Australia is much more difficult than collecting round the British Isles. The greatest disadvantage here is the lack of any well-marked tide, except on the North-West coast. The average tide at Fremantle is only about one or two feet, and the intervals between high tides are irregular, the time usually being about twenty-four hours. Hence one has to rely on dredging expeditions or on the chance of the weeds being thrown up after storms.

IN THE DARLING RANGES.

There is much very interesting and important work before the future collectors of marine Algæ along the coast of Western Australia. Just as around the coasts of the British Isles the Fucaceæ are, on the whole, the most conspicuous weeds. In Western Australia, however, the number of species of Fucaceæ, or other Phæophyceæ is limited, and it is the Rhodophyceæ that are represented by far the greatest variety of species. A great many of the West Australian Algæ are apparently not found elsewhere. Those which are not peculiar to the region are found commonly on the shores of the Indian Ocean, while some are common all over the world in the same latitudes.

The best collections have been made on the rocks at Rottnest Island, Garden Island, Fremantle, and near Albany, and many specimens have been obtained by dredging in Fremantle Harbour and in King George's Sound.

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Two rare specimens of Verticillatæ– *Acetabularia calyculus*, and *Polyphysa cliftoni* have been dredged at Fremantle. *Polyphysa cliftoni* is a very delicately beautiful weed having a long stalk (about three inches long) with a tuft of fronds about three-eighths of an inch long, at the top. This species has only been obtained once ; it seems to be of very rare occurrence.

A GOLDFIELDS GARDEN, THE RESULT OF THE WATER SCHEME.

The Chlorophyceæ found here include many species of Caulerpa and several species of Codium, and Cladophora. Some of these are found in the Swan River. The Siphoniaceæ are particularly abundant in places. Many species of Codium occur on the rocky coasts of the Abrolhos Islands. A rather curious form *C. mammilosum* is often found thrown up on the beach between Geraldton and the Leeuwin. Several species of Halimeda occur along the coast. *H. macroloba* (common to the Indian Ocean) occurs on Rottnest. They are more abundant at Geraldton and probably farther North. The Valoniaceæ are represented by *Struvea macrophylla*, only found at Champion Bay, *S. plumosa* found at Rottnest, and *Penicillus arbuscula* also found at Rottnest.

The Fucaceæ and Dictyotaceæ are well represented among the Phæophyceæ. *Cystophyllum muricatum* is one of the commonest sea weeds found on the coast. It generally grows in sheltered harbours and in such situations is often much covered with minute Zoophytes. *Dictyota furcellata* is exceedingly abundant on the shores of Western Australia. It covers the bottom in about four or five fathoms of water. It is very common in the Princess Royal Harbour in King George's Sound, and also at Fremantle. *Dictyota fastigiata* is found cast ashore from deep water, at Fremantle, Rottnest, King George's Sound, and Flinders Bay.

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The Florideæ are very varied and abundant. Many well-known British genera are well represented here, as for example, Polysiphonia, Callithamnion, Plocamium, Delesseria, Nitophyllum, Ceramium, Corallina, and Griffithsia. The two species of Ceramium found, grow on brown Algæ at Fremantle, Rottnest, and Garden Island. Lithothamnia are very common on the Abrolhos Irslands, as well as other places on the coast.

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The Zoology of S.W. Australia.*

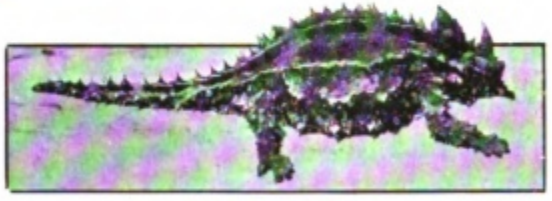
THE State of Western Australia is of such vast area and extends into such diverse climatic zones that it would be impossible in a few pages to give even a few details of the Zoology of the region.

In the following pages a very brief account is given of the South-Western portion of the State. This region will be visited by the excursion parties during the visit of the Advance Party to Western Australia. It may be considered (quite arbitrarily) for our purpose as extending as far North as Shark's Bay, and as far East as Kalgoorlie.

Very much work indeed remains for zoologists in the Western State of Australia. Isolated small collections have been made from time to time and the birds and mammals collected rather more thoroughly than other groups. The Hamburg expedition of 1905 made a great advance in the knowledge of the invertebrata, both land and marine, of this region, and the West Australian Museum has, since its opening, received specimens and, more recently, has taken a greater part in collecting work. Unfortunately the great lack of literature is a stumbling block to the systematist desirous of working on the spot.

South-West Australia is for the greater part a dry region, for although Perth receives about 34 inches of rain annually, the rainfall diminishes rather regularly as one recedes from the coast. Of the rain that does fall, however, most is precipitated during a few months of the year (winter months) and consequently there are very long dry periods. This renders the country much less suited for animals and plants requiring a moist climate than if the rainfall was more uniformly distributed through the year.

The country is favourable for "dry land" animals, and everywhere one can be sure of insects, arachnids, myriapods and reptiles. The arid and other regions of Central Australia are no barriers to many of the species, and consequently very many forms are common to both East and West Australia.



A MOUNTAIN DEVIL.

It is impossible, however, to speak of the distribution of the larger groups of animals in a few lines. In some cases a very large number of species of an order or class are peculiar to S.W. Australia. In other cases, a large number are to be found on the Eastern side of the Continent. Too little is known yet to write

* By Professor W. J. Dakin, D.Sc., and Mr. W. B. Alexander, M.A.

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definitely. So far as the birds are concerned, S.W. Australia forms a distinct region, many Northern and Eastern forms being absent. Again, many mammals are peculiar to the region and others again are characteristically absent. The same thing applies to the reptiles; some few species are peculiar to the region, but others are to be found almost all over Australia. Of the land animals inhabiting more moist situations we have one characteristic species of Peripatoides and perhaps two. The Oligochaeta, however, show no special South-Western characters, although some are peculiar to the region. Of aquatic animals those which can resist drought occur abundantly. Fresh water sponges occur occasionally, but are, on the whole, rare. Ostracods, large Phyllopods and Planaria

SCENE AT BROOME, THE HEADQUARTERS OF THE PEARLING INDUSTRY.

occur in road puddles and rock pools inland, made by a few showers of rain and heated up to extraordinary temperatures by the blazing sun. Only 12 species of the Batrachia out of 60–70 known for the Continent occur in the South-West. The region has probably derived its batrachia entirely from the other States. There are, unfortunately, no large perennial lakes in S.W. Australia, and most of the smaller streams dry up in summer. Mundaring Weir Lake is comparatively new, and no plankton collections have yet been made there. The fresh water plankton remains, therefore, for future investigation.

Crayfish abound in the rivers of the coastal regions, three species being represented. They are all species of an almost peculiar West Australian genus, no species of which occur in Eastern Australia.

Marine Fauna.—The coast of S.W. Australia does not provide good shore collecting, for the tides are very small and the fluctuations do not seem to be regular. Usually there is an interval of 24 hours between two successive "low tides." For a great part, the coast is a level region with great stretches of sand, on which the surf breaks continually. The sea bottom close to the shore often consists of sandy areas with forests of weed. These seaweed meadows have proved rather barren to the zoologist. A rich fauna has, however, been found

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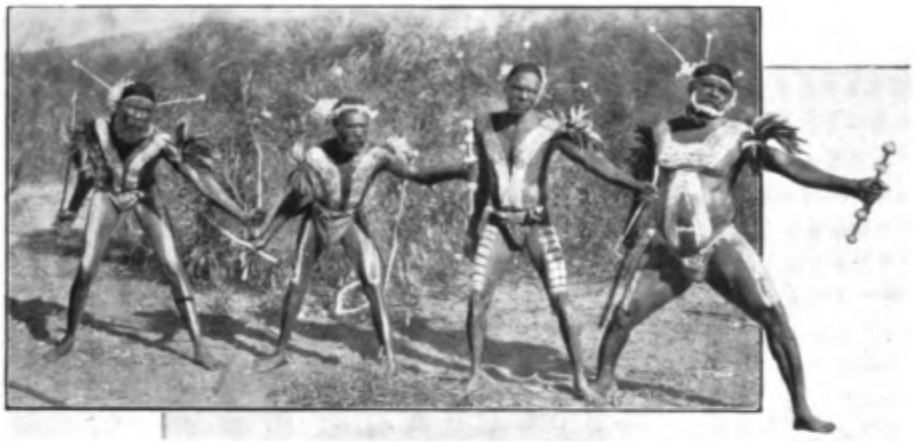
in the rocky bottoms, especially between some of the islands and between the islands and the coast, and there is no doubt that systematic dredging would reveal many rich collecting grounds.

Particularly good collecting grounds occur on the Abrolhos Islands, and also in Shark's Bay; especially striking being the variety and number of the sponges and ascidians. The fauna of Shark's Bay—the most northerly point on the coast



ARRAYED FOR THE CORROBOREE.

in the S.W. Area—is almost tropical. Reef corals occur, but not frequently, as reef builders. There are many tropical Gorgonids, Alcyonaridae and Mollusca. A rapid diminution in the number of the tropical species occurs as one follows the coast southward, and at Albany there are some typical Antarctic elements. King George's Sound, Albany, has been more frequently investigated by collectors of marine organisms, and the famous expedition of Quoy and Gaimard collected much material there. A curious anomaly is found if we take into consideration the Abrolhos Islands situated 50 miles away from the coast—off Geraldton. Here the fauna appears to consist of a mixture of tropical and extra tropical species. The islands are particularly interesting, for great coral reefs occur. As, however, an investigation is at present being made*, it will be better to wait for results than to build theories on the little known at present. On the whole, the fauna of the coast is quite extra-tropical, and too little is known to make comparisons with the Indian and African coast faunas.

MAMMĀLIA.

About 80 species of mammals have been recorded from the South-West region of the State. The different groups are represented as follows:—

Monotremata, one species.
Marsupials, 44 species.
Cetacea, nine species.
Rodentia, 11 (counting three introduced species).
Carnivora—
(Fissipedia) two (counting domestic cat).
(Pinnipedia), three species.
Chiroptera, 10 species.
Ungulata (all introduced).

The marsupials outnumber the other groups, but 12 of the 44 species are only found as fossils.

* Percy Sladen Expedition to the Abrolhos Islands, November, 1913.

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Of the Monotremes only Echidna occurs in West Australia.

The marsupials found in the region include some which are peculiar to the area, others which are found in South Australia, and species whose range extends across Australia to the East Coast. Many Eastern species are missing in W.A.

Three species of Perameles occur in the region. The interesting banded ant-eater (*Myrmecobius fasciatus*) is one of the most characteristic forms of the region, and is found elsewhere only in the adjoining parts of South Australia.

The Native Cat (*Dasyurus Geoffroyi fortis*), common to all Australia, is represented, and another interesting Dasyure is Thylacinus, the Tasmanian Wolf, found as a fossil in the caves of the South-West. Here there is also represented the fossil Tasmanian devil (*Sarcophilus harrisi*).

Several of the Phalangers or "Australian Opossums" are to be found in the region under consideration, and one or two species are peculiar to it. Mention must also be made of the very interesting *Tarsipes spenserae* which is peculiar to S.W. Australia. It is only about the size of an ordinary mouse, and possesses an extensile tongue which is used to abstract the honey from flowers. Its distribution appears to be restricted to the district round Albany.

The Wombats are represented in the South-West by a fossil species from the caves—peculiar to the State and named *Phascolomys hacketti*.

The two species known of the giant marsupial, Diprotodon have been found represented by some beautiful fossil remains in the same caves of the South-West.

Eighteen members of the family Macropodiidae occur in our district. The kangaroos and wallabies are, however, growing rapidly more scarce with the advance of the farmer and settler. The largest of the living Australian

AUSTRALIAN NATIVES.

kangaroos—the Great Red Kangaroo, probably just invades the South-Eastern portion of the State, a district which is, strictly speaking, outside the South-West region.

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Another large form, the common or Great Grey Kangaroo (*M. giganteus*) is common to all Australia, and is represented by a variety in the South-West.

Wallabies abound in the area and occur also on some of the islands situated several miles away from the coast.

Reference has already been made to certain of the fossil marsupials. These fossils have been found chiefly in the Mammoth Cave and Bride's Cave, and in addition to the species mentioned remains have been found of a giant Echidna, a giant kangaroo (*Palorchestes azael*, Owen); a gigantic kangaroo-rat (*Sthenurus occidentalis*, Glauert), together with a number of other species not very different from living forms. At the time of writing, the Western Australian Museum is having further investigations made and with exceedingly good results. Doubtless many more new species will be discovered.

OPENING SHELL ON A LUGGER.

Little need be said of the Cetacea. In days gone by there were great whale fisheries in some of the bays along the coast, and a revival is now taking place. A Norwegian Co. and two local companies with a united capital of £168,000, have licenses to fish. The Humpback Whale is the most common, and next comes the Sperm Whale, the Fin Back, Sulphur Bottom and Right Whale. Ninety-eight sperm whales were captured in the vicinity of Albany in 1912.

Only eight species of rodents occur in the South-West (exclusive of the common mouse and brown and black rats, which have been introduced). The rabbit has also invaded some parts of Western Australia, but is not such a pest as in the Eastern States.

The dingo is still a source of annoyance to sheep farmers.

No frugivorous bats have been recorded from the South-West, although several species of Megachiroptera are known from Australia. Seven species of Microchiroptera are listed, all belonging to the family Vespertilionidae. None are peculiar to the State.

BIRDS.

The South-West of Australia forms a distinct region characterised firstly by the absence of a number of Northern and Eastern genera, and secondly by the fact that a large proportion of the species are recognisably distinct from their Eastern congeners, though in many cases the differences can only be regarded as of subspecific value.

Of about 100 genera endemic in Australia some 66 occur in the South-West, the most notable absentees being the Lyre-birds, Menura. The Papuan elements in the Australian avifauna, of which the Cassowary, Megapodes, Fruit-pigeons,

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Weaver-finches, Bower-birds, Ant-thrushes, and Rifle-birds are the most striking examples, are entirely absent or represented by very few species.

There are no genera confined to the district, but a few forms such as Porphyrocephalus (the King Parrot), Lacustroica (White's Honey-eater), and Eremiornis (the Desert-bird) are peculiar to the West of the Continent; whilst the genus Amytornis (Grass-wrens) has its headquarters in the West and extends across the interior.

The Western Australian species do not appear to differ from their eastern congeners, according to any definite rule; they are sometimes smaller, sometimes larger, sometimes duller in plumage, sometimes more brilliant. The Magpie (Gymnorhina), Spinebill (Acanthorhynchus), and some others have longer beaks than the corresponding forms in the East.

Undoubtedly the most prevalent colouring is a combination of black and white, such as is seen in a number of familiar species, *e.g.*:—The Magpie, (*Gymnorhina dorsalis*), Magpie Lark (*Grallina picata*), White-shouldered Caterpillar-eater (*Lalage tricolor*), Restless Flycatcher (*Sisura inquieta*), Wagtail (*Rhipidura tricolor*) and White-fronted Chat (*Ephthianura albrifrons*).

Birds of brilliant plumage are numerous. Amongst them may be mentioned the Red-eared Finch (*Zonæginhtus oculatus*), the Scarlet-breasted Robin (*Petræca campbelli*), the Blue Wren (*Malurus splendeus*), the male of which is perhaps the most brilliant blue bird in the world, the Red-winged Wren (*M. elegans*), the

THE "SWAN" RIVER.

Mistletoe-bird (*Dicæum hirundinaceum*), the Spotted Diamond-bird (*Pardalotus punctatus*), the Tricoloured Chat (*Ephthianura tricolor*), the Bee-eater (*Merops ornatus*), the purple Kingfisher (*Alcyone pulchra*), and many species of Cockatoos and Parrots.

Whilst none of our birds can be placed in the front rank as songsters, there are a number whose notes are very melodious. Most Australians give first place to the Magpie, which has a great variety of notes at its command, and is heard at its best in the early morning in the bush. The Reed Warblers, Songlarks, Thickheads, Songthrushes, Shrike-robins, and many of the Honey-eaters are also

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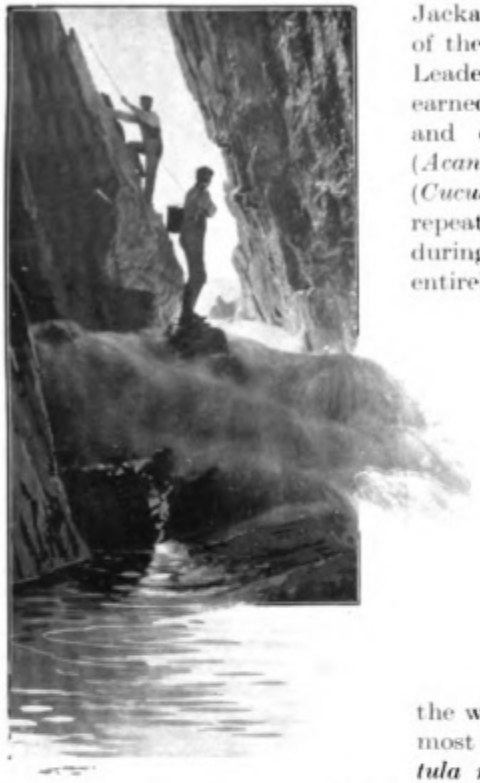
minstrels of no mean order. Of birds which utter loud or curious calls the Kookaburra or Laughing Jackass is the most famous. Curiously enough the genus occurs wild all over Australia except the South-West, to which it has only been recently introduced, but where it appears to be flourishing. The Butcherbrid (*Cracticus destructor*) is often known as Little Jackass from the similiarity of its laugh to that of the Kookaburra. The loud harsh cry of the Leaden Crow-shrike (*Strepera plumbea*), has earned its name of Squeaker; another noisy and quarrelsome species is the Wattle-bird (*Acanthochæra carunculata*). The Pallid Cuckoo (*Cuculus pallidus*), like its European relative, repeats its loud call with persistent iteration during the spring. The notes are, however, entirely unlike those of its famous namesake.



AMONGST THE ROCKS AT CAPE NATURALISTE.

At night time in the bush the call of the Boobook Owl (*Ninox ocellata*) is often heard, but is usually attributed to the Frogmouth (*Podargus*), which has thus earned the spurious name of Morepork. Other birds whose calls have earned them their names are the Bell-bird and the Twenty-eight. The latter (*Barnardius semitorquatus*) is the commonest species of parrot in the Jarrah forests and its cry when disturbed is distinctly like those words.

Of flightless birds we possess three, the well-known Emu, still frequent except in the most settled districts, the little Penguin (*Eudyptula minor*), colonies of which occur on many of the islands off the coast, and the Noisy Scrub-bird (*Atrichornis clamosa*). The latter is, or was, an inhabitant of the thick scrubs on the South coast between Albany and Cape Leeuwin, but as it is now many years since the last individuals were seen it is almost certain that the species is extinct, a result probably brought about by the introduction of cats. The only other member of the genus, unique among Passerine birds is found in the thick tropical scrubs of northern New South Wales.

It is noteworthy that a number of other species of our avifauna appear to be approaching the flightless condition; these include the Steamer or Musk Duck (*Biziura lobata*), common on the coastal lakes, and the Field Wren (*Calamanthus campestris*), Coachwhip bird (*Psophophotes nigrogularis*), Emu Wren (*Stipiturus malachurus*), Bristle-bird (*Sphenura*), Grass Wren (*Amytornis*), and Grass-bird (*Megalurus gramineus*), all of which inhabit low scrubs either on the coast or in the interior.

In conclusion we must refer to the Gnou or Mallee Hen (*Leipoa ocellata*) which like the other members of its family forms a large mound of sand and dead leaves in which it deposits its eggs. These hatch by the heat of the sun aided by that derived from the decaying vegetation, and the young birds can fly as soon

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as they are hatched and at once lead an independent existence. The Mallee Hen was formerly plentiful, but is now rarely met with.

REPTILES.

This class is represented in South-Western Australia by members of three of its orders.

Chelonia.

Examples of more than one of the marine turtles which frequent the northern coasts of the State in such numbers are at times captured off the southern part of the coast-line. The one most usually met with is probably the Logger-head (*Caretta caretta*). The Green Turtle (*Chelonia mydas*), breeds as far south as the North Island of Houtman's Abrolhos. The long-necked Tortoise (*Chelodina oblonga*) is very plentiful in the coastal swamps and rivers.

Lacertilia.

No less than 70 species of lizards are known to inhabit South-West Australia, and there can be little doubt that systematic collecting would considerably increase this figure. Geckoes number 15 species, many of which are quite common, but their small size, comparatively slow movements, and dull colours render most of them inconspicuous. These remarks apply specially to the species of Phyllodactylus and Diplodactylus, for the common *Gymnodactylus miliusii* is rendered conspicuous by its black and white colouring. It is also remarkable for its very curious short, flat tail, which is extremely broad at the base. Six members of the family Pygopodidae, which is peculiar to Australia, are found in

A FARMER'S DAIRY HERD.

our area. These are entirely limbless forms, commonly mistaken for snakes, and remarkably similar in appearance to the Anguidae or Slow-worms of the Northern Hemisphere, to which they are not specially related.

Thirteen species of Agamidae are recorded, of which eight belong to the genus Amphibolurus. These are long-legged and long-tailed forms, remarkable for the development of striking markings on the head and frills on the neck at the breeding

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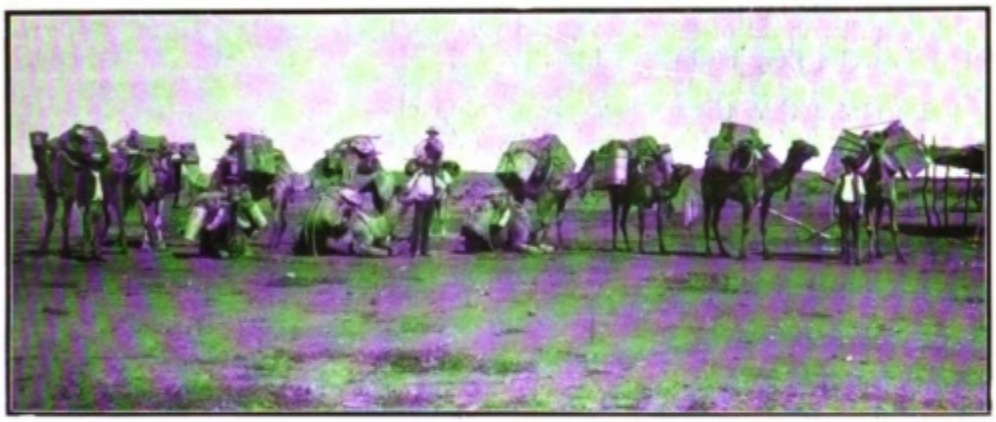
season. Our most peculiar lizard, the Mountain Devil (*Moloch horridus*), is also a member of this family. It is not uncommon, especially in the drier regions, extending as far east as Central and South Australia. This animal is covered all over with stout spines, and has, in addition, a curious fleshy excrescence on the back of the neck, its sharply contrasted brown and yellow colours add to its formidable appearance, but it is in reality a very harmless creature. Its mouth is extremely small and it appears to feed exclusively on ants.

The Varanidae are represented by two species of Varanus, of which *V. gouldii* is the common form. It is usually called the Goana or Bungarra, and grows to a length of considerably over six feet. It is completely terrestrial, living in an underground burrow, which it presumably excavates for itself. The remainder of our lizards belong to the family Scincidae. The most familiar is the Bob-tail (*Trachysaurus rugosus*), which is very sluggish in its habits. The species of Egernia



THE CAMEL HAS BEEN THE KEY TO THE DRY INTERIOR.

are good sized lizards, of which two (*E. stokesii* and *E. depressa*) have flat spiny tails, the rest having the tail long and cylindrical. The genus Lygosoma, of which we have 20 species, contains most of our common small active lizards as well as species in which the limbs are entirely absent. Connecting these two extremes are numerous species with the limbs more or less reduced and bearing only three, two, one or no digits.

Ophidia.

Of our 24 species of snakes 19 are venomous, and with the exception of the Carpet Snake (*Python spilotes*), none of the others are very common. This handsome species attains a length of considerably over six feet, and feeds chiefly on small birds and opossums.

The two or three species of Typhlops are small, pale-coloured worm-like reptiles, which are quite blind, and spend their lives underground, feeding on ants.

Of the many sea-snakes found in the North-West only one, the black and yellow *Hydrus platurus*, extends into temperate waters. It is not infrequently washed ashore on the beach at Cottesloe. Of the venomous snakes, Elapinae, some are too small to be formidable, such being the black and white Ringed Snake (*Furina bimaculata*) and the Crowned Snake (*Denisonia coronata*). Of the deadly snakes the Brown Snake (*Demansia nuchalis*), the Black Snake (*Pseudechis*

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porphyriacus), the Copper-head (*Denisonia superba*), the Tiger Snake (*Notechis scutatus*), and the Death Adder (*Acanthophis antarcticus*) are the best known. The latter is especially formidable, since it does not move when approached, and is therefore much more liable to be trodden upon than the others which are more timid. It is also interesting because it possesses a spine at the tip of the tail: apparently this is used as a decoy being protruded from beneath the dead leaves under which the snake lies concealed. By waving it about the snake lures inquisitive birds within reach and then springs upon them.

BATRACHIA.

This is the only group of Amphibia represented in Australia, between 60 and 70 species being recorded from the continent. Of these, only 12 occur in the south-west. The only paper on the West Australian Batrachia published hitherto was written by Mr. J. J. Fletcher, in 1897, but as no further species have been recorded in the southern part of the State since that date, his conclusions as to the affinities of the species may be quoted here.

He states that the south-western group of species is characterised by the poor representation of the two dominant Australian genera Limnodynastes and Hyla, or indeed of any genus except Crinia, which is not numerically strong in species; by a poverty of peculiar genera (1) and species (2); and by the absence of Chiroleptes, a characteristic which it shares in common with the south-eastern fauna. Four of the species are represented in Tasmania and Victoria, three in South Australia, five in New South Wales, three in the Northern Territory, and only one in Central Australia. He concludes that, though South-Western Australia is now practically isolated, except on the north, yet there is clear evidence of former relations with Victoria and Tasmania and with the Centre. Its Batrachian fauna, as we know it, is a poverty-stricken one, with but little if any marked character of its own, and may well be mainly, if not altogether, of derivative origin.

A FINE SPECIMEN OF THE ABORIGINAL NATIVE.

Of the 12 species six belong to the family Cystignathidae, the commonets being *Limnodynastes dorsalis*, which deposits its spawn in ponds in circular floating patches and *Crinia signifera*, the Brown Froglet, a very small species, which attaches its small submerged bunches of ova enclosed in clear jelly to stems and reeds.

Both our species of Bufonidae are burrowing forms, with tubercles developed on the hind limb which increase the area of the effective digging surface, and both are confined to the State. *Myobatrachus gouldii*, the sole species of the genus, is the most peculiar form, remarkable for its very stout body and small head. It is believed to live largely on termites.

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We have four species of Hylidae, of which two are common. *Hyla aurea* is our largest marsh-haunting frog, occurring in great numbers in the swamps about Perth, where it may be observed sitting high up on the leaves of the reeds. *Hyla adelaidensis* is a smaller form found in bushes on the banks of streams; it is bright green or brown in colour, according to its surroundings, and is thus inconspicuous until it jumps, when it reveals a bright orange patch at the back of the thighs.

CYCLOSTOMATA AND FISHES.

About 200 species of fish have been recorded from South-West Australia. Most of these are represented in the collection of the Western Australian Museum.

The Cyclostomata are represented by a single form, *Geotria australis*, Gray, which is found also on the East.

Eighteen species of Elasmobranchs have been recorded, of which number, six are rays. The Port Jackson Shark (*Heterodontus philippi*) is common, and specimens are frequently caught at and near Fremantle. The Lamnidae are represented by two well known species (*Carcharadon carcharias* and *Alopecias vulpes*), both forms being common over a wide region. The same applies to the other sharks, of which may be mentioned *Carcharias tricuspidatus* (Blue Nurse), *Squatina squatina* (the Angel Shark), *Pristis zysron* (the Sawfish), and the following genera.:—Paraseyllium, Orectolobus, Catulus, Prionace, Mustelus, Sphyrna, Hypnos,

IN THE HEART OF THE CONTINENT. A WATERING PLACE ON THE STOCK ROUTE.

Rhinobatus, Trygonorrhina, Trygon and Myliobatis. Although sharks appear quite common off the coast, they never seem to have made any of those disastrous attacks on man which are at times recorded from the Eastern Coast of Australia.

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It is impossible to discuss here the distribution of the teleostei recorded from the south-west ; Indian forms are represented but the majority appear to be Australian. It may suffice to mention some of the more prominent food fishes. Familiar English names have been given to many of these, but the genera are often very different. Perhaps the most valuable fish is the schnapper (*Pagrosomus auratus*), one of the Sparidae (Bream). The same family is represented by *Sparus sarba* and *S. Australis*, the black and silver bream respectively. Another fish caught in large numbers is the sea mullet (*Mugil dobula*) which has been smoked and canned at Mandurah, a fishing port, some miles south of Fremantle. This mullet is fished in large quantities in the Swan River near Fremantle.

ABORIGINALS IN WAR PAINT.

Another important food fish is the Whiting, but several species come under this title, all of the genus Sillago, of the Indo-Pacific family Sillaginidae. The Pleuronectidae are poorly represented by the " Flounder " (*Ammotretis rostratus*). The genus Balistidae (Trigger or File fishes) is represented amongst the food fishes by the Leather Jacket. Herrings can be bought at the Perth Fish Market, but the species will probably be *Arripes georgianus*, a member of the family Arripididae. The Australian Salmon (*Arripes trutta*) is a member of the same genus, and both " herring " and " salmon " belong therefore to a group which is but remotely related to that (the Clupeiformes) which contains the familiar English herring and salmon.

Amongst other prominent food fishes are the Jew Fish (*Glaucosoma hebraicum*), probably peculiar to Western Australia, the King Fish (*Sciaena antarctica*) the Skipjack (*Caranx platessa*) ; the Tailer (*Pomatomus saltatrix*) ; the Garfish (*Hyporhampus, sp.*) ; " Pike " (*Sphyraena, sp.*) ; Groper (*Archaerodus Gouldii*) and others. Gadoid fishes are unrepresented. The Mackerel group is represented by two genera in the south-west, but neither plays any part as a food fish.

Of other teleosts it may be said that the Goby and Blenny families are found along the coast, and round about the jetties large shoals of small " Blow Fish," belonging to the Tetrodontidae, occur at times and make themselves a perfect nuisance to the fishermen. Another fish of somewhat remarkable appearance is the Box Fish (*Ostracionidae*) characteristic of tropical seas and represented by two species of the genus Arcana.

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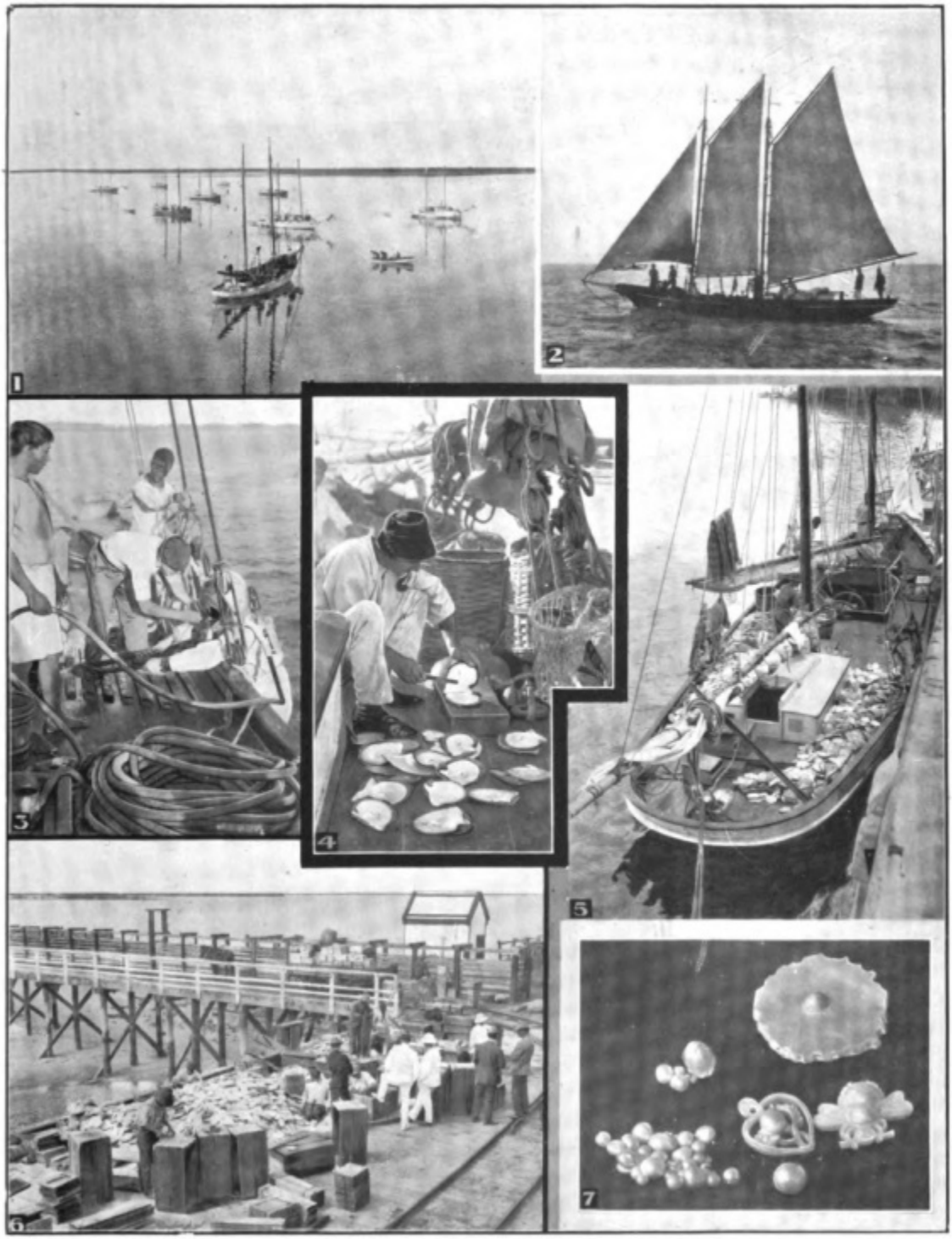

THE PEARLING INDUSTRY.

1. LUGGERS AT ANCHOR.
2. MAKING FOR THE PEARLING GROUND.
3. A DIVER DESCENDING.
4. OPENING THE SHELL.
5. A VALUABLE CARGO.
6. PACKING SHELL FOR EUROPE.
7. PEARLS AND BRITANIA.

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CEPHALOCHORDA.

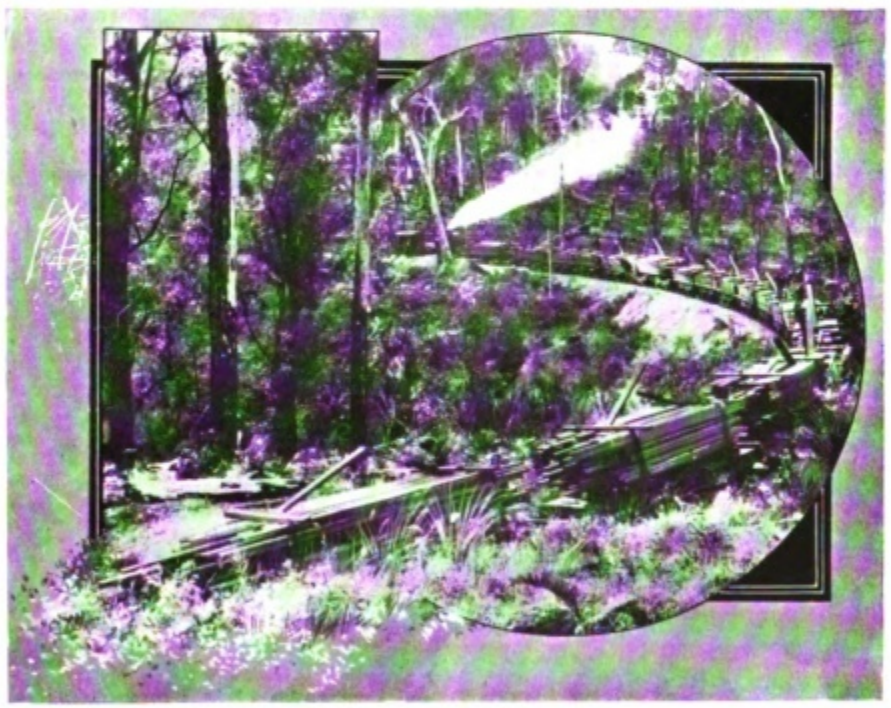
Only one specimen of Amphioxus has been obtained on the West Coast of Australia. This was obtained in Sharks' Bay. No report has yet been made on the specimen.

ENTEROPNEUSTA.

The first Enteropneust to be obtained on the West Coast of Australia was captured on the reefs of the Abrolhos Islands during November, 1913. It has not yet been completely investigated, but appears to be a new species of Ptychodera.

TUNICATA.

Tunicates and Sponges are amongst the most common animals on the West Coast of Australia. The piles of the jetties at all the sea-ports are covered with them. Unfortunately, whilst large collections of Ascidia have been made and reported on from other parts of the Australian coast, no reports are yet to hand in connection with the West Australian species. Out of 183 species given in Herdman's list of Tunicata of the Australian Museum, only six are recorded for West Australia. The Hamburg Expedition captured one Doliolum species, no



FROM MILL TO MARKET.

specimens of Pyrosoma or Salpa, but a large number of Appendicularia. The Sharks' Bay species were *Oikopleura cophocerca*, *O. rufescens*, *O. longicauda*, *O. fusiformis* and *O. dioica*. All these, except the last, are characteristic of the tropical region of the three great oceans. The last species occurred also near Fremantle, alone or with *Fritillaria Abjornseni*. It is a coastal form of very wide distribution.

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THE CRUSTACEA.

Very much work remains to be done in collecting and working out the Crustacea of Western Australia. Many hundreds of species not yet recorded must occur, and this applies particularly to the division Peracarida. Only about 15 species of Decapoda are definitely recorded for W.A. in Haswell's Catalogue of the Australian Malacostraca in 1882. Since then very few published records have added names to the lists. The Amphipoda and Isopoda particularly need collecting. Decapods are numerous on the reefs and rocks of the coast, but many of the collections already made have not yet been reported upon. The fresh water Crayfishes are much better known. The characteristic genus is Chaeraps, no species of which occur on the eastern side of Australia; the only other known species being *C. quadricarinatus* of the extreme North of Australia and New Guinea. Three species of Chaeraps are to be found. *C. quinquecarinatus* (the Jilgy or Gilgie) which is common in the streams round Perth and in the rivers as far south as the Vasse. *C. tenuimanus* (the Marron) a large form inhabiting the rivers of the extreme south-west, and *C. preissii* found in small streams and ponds from the Harvey River to the Margaret river in the south-west.

RETURNING FROM THE HUNT.

The place of the Lobster of the English coasts is taken here by a species of Spiny Lobster, *Palinurus penicillatus*, which is very abundant and is to be seen on carts in the streets. The number sold at Fremantle in 1912 reached a total of 14,199 dozen, their value being £4,259. Other common decapods which are of considerable commercial importance are the "Prawns." There are three common species, one of which closely resembles *Peneaus macleayi* of the East; the others are *P. canaliculatus* and *P. monodon*. They are fished in the Swan River and consumed largely in Perth and district.

Perhaps the most common crab of the coasts is *Leptograpsus variegatus*. It may often be seen scuttling over the rocks some distance away from the water. Burrowing crabs occur in large numbers on the sandy beaches, especially in the north of the district considered where Ocypoda sp. is common. Amongst other decapods may be noted *Neptunus pelagicus*, the common crab of the Swan River, a species found also in the Indian waters and on the Eastern coast of Australia. *Thalamita phyrna*, *T. stimpsoni*, and *Liolphus planissimus*. Most of the common brachyura appear to be widely distributed, and generally occur in the Indian Seas.

Stomatopoda are probably common in places along the coast. Seven species have been recorded, of which six are tropical Indo-Pacific forms.

Of the freshwater Phyllopoda, which occur so abundantly in the State during the wet season, 15 species are known. Three of these are to be found in the Eastern States, the others are peculiar to W.A. Both Apus and Lepidurus are to be found.

ONYCHOPHORA.

Two species of Peripatus have been obtained in Western Australia: *Peripatoides occidentalis* at Bridgetown and *P. gilesii* in the Darling Ranges near

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Perth. The former has only been obtained on one occasion, (1), but the latter is comparatively well known. According to Bouvier the Western Australian species are most closely allied to *P. orientalis* from Eastern Australia and *P. suteri* from New Zealand.

MYRIAPODA.

It appears that the Myriapod fauna is typically Australian in character, very few of the Oriental types found in other parts of the continent having penetrated to the south-west. Of 58 species obtained by the Hamburg Expedition, 35 were described as new, and most of these are presumably confined to our area. The

GARNERING THE GOLDEN FLEECE.

most interesting fact in connection with the affinities of the West Australian members of the order is that two species are apparently identical with South African forms, whilst two others belong to genera previously only known from South Africa.

Chilopoda.

Centipedes are very plentiful, though the common species are comparatively few. One of the largest is *Ethmostigmus rubripes*, which may be distinguished by its black head; whilst *Cormocephalus turneri*, bluish in colour, with a red head, is very abundant. The only representative of the long-legged Centipedes, Scutigeridae, is *Allotherena maculata*, which is frequent throughout the south-west.

(1) Peripatus occidentalis has been found once again in the State, twenty years after its first discovery, and not far from the original habitat. (Dakin).

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Diplopoda.

One of the largest of these is *Dinocambala ingens*, one of the Juloidea. A common representative of the Polydesmoidea is the handsome yellowish-brown or chestnut *Antichiropus variabilis*.

Symphyla.

Scutigerella indecisa, our only representative of this interesting group, is very common in moist situations under logs.

INSECTS.

The insect fauna of South-West Australia is extremely rich in species. At first sight this does not appear to be the case, as, except in very favoured places or under unusual circumstances, it is difficult to obtain a great variety in a short time. Further experience, however, reveals the fact that every collecting trip results in the capture of new species, and it would take many years to exhaust even a very limited area.

THE SWAN RIVER PROVIDES MAGNIFICENT ROWING WATERS.

Of the various groups it is noteworthy that practically all the families of the more primitive Orders, Orthoptera and Neuroptera, are represented in our fauna, whilst the modern and specialised Butterflies are very few. Probably no other equal area in the warmer parts of the world has so few species of this group. Coleoptera are very numerous, Weevils and Buprestidae, both families which are known from the evidence of fossils to be ancient types, being specially well represented. Some of the groups of Hymenoptera are also extremely rich in species.

Thysanura.

The common Silver-fish, *Ctenolepisma longicaudata*, is a great pest in houses, destroying paper and clothing. It is an African species and was probably introduced to the colony in its early days when most of the ships called at the Cape. *Japyx longiseta* is the sole representative of its family, and no Machilidae are at present known.

Collembola.

This order is fairly well represented but no species are at present described. One of the Sminthuridae sometimes occurs in such numbers on lucerne crops as to do considerable damage. A species of Anurida, very similar to *A. maritima*, occurs on the coasts below high-tide mark, and several other species of Poduridae occur. The Entomobryidae are also represented by numerous species.

Dermaptera.

Six species of earwigs are at present known, of which four are endemic. The largest species is *Labidura truncata*, whose male has very long forceps; *Gonolabis woodwardi* is perhaps the commonest.

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Orthoptera Cursoria.

Cockroaches are very well represented, about 50 species being known. The great majority of these are wingless, and over half belong to the genus Polyzosteria and its allies. It is only on the occasion of a bush fire, when they are driven out by the heat, that the number and variety of cockroaches in the bush is strikingly demonstrated.

Orthoptera Gressoria.

The Mantidae and Phasmidae are all known locally under the name of Mantis. Several of the latter are beautiful mimics of sticks and are consequently not often noticed. The best known member of this family is *Podacanthus viridiroseus*, the pink-winged Phasma.

Of the Mantis family proper there are a considerable number of species. The most common are the long brown *Archimantis sobrina*, the little green *Orthodera ministralis*, and the small dark brown ground species *Paroxypilus tasmaniensis*, whose wingless female has a leaf-like flattened body.

Orthoptera Saltatoria.

Of the Acridiidae one of the most remarkable is the long-nosed species *Acrida conica*, whilst the ridge-backed species of Goniaea are very inconspicuous amongst dead gum leaves. The largest common form is the blue-winged Locust (*Coryphistes cyanopterus*), which generally rests on tree-trunks. Fortunately none of the species have been known to occur in sufficient numbers to do any considerable amount of damage. Locustidae are also numerous, perhaps the most interesting is *Caedicia longipennoides*, whose elytra are wonderfully like the leaves of eucalyptus in shape, colour and markings. Of the Gryllidae the

THE SLEEPER-HEWER AT WORK.

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two commonest species are burrowing forms, the Mole-cricket (*Gryllotalpa coarctata*), and the Sand-groper (*Cylindracheta kochii*). The species is only known from the vicinity of Perth where it is abundant in sandy soil.

Isoptera.

The Termites are unfortunately only too numerous, and nearly 20 species are known. On mild afternoons in the winter, when the perfect insects are emerging, the air is sometimes so thick with them locally as to recall a slight fall of snow. Most of our species do not form mounds above ground, hence their

IN THE EASTERN AGRICULTURAL DISTRICTS.

presence is not suspected until one turns over logs or pulls up stumps. The one exception appears to be *Coptotermes lacteus* which forms a rather regular dome-shaped nest from two to four feet high.

Odonata Copeognatha.

Five species of Psocids were obtained by the Hamburg Expedition. Owing to the researches of Mr. Tillyard of Sydney, some thirty species of Dragon-flies have been recorded from the south-west. Of these a few only are peculiar, whilst a number of others differ slightly from their congeners in the eastern part of the continent. The widely distributed large species (*Hemianax papuensis*) is much the commonest form.

Mecaptera.

Harpobittacus australis, our only Scorpion-fly, is very plentiful in the earlier part of the summer.

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Neuroptera.

This group of insects is well represented, members of almost all the families being found. Ant-lions, Myrmeleonidae, are particularly plentiful and will probably prove to be more numerous than the Dragon-flies. *Acanthaclisis fundatus* is the commonest large species.

Of the Ascalaphidae the most striking is *Stilbopteryx costalis*. *Acmonotus magnus* is a beautiful and curious form with very long fragile antennae and a blue and yellow body.

The Mantispidae are represented by more than one species of Mantispa.

Trichoptera.

The Caddis-flies are not numerous, though it is probable that many species will be added to the meagre list of four at present described.

Hymenoptera.

Of this order some families are extremely abundant, especially the flower haunting Thynnidae and Apidae. On the other hand certain other families are hardly represented, among which are the Vespidae or true wasps and hornets. Ichneumonidae too are not very plentiful, their rôle in keeping down the larvae of Lepidoptera being played by species of Diptera. Female Mutillidae are not uncommon, though the males are rarely seen. Scoliidae and Bembecidae are fairly plentiful, whilst members of the families Pompilidae, Sphegidae and Eumenidae are all known locally as hornets. These attract attention owing to their habits; especially is this the case with *Eumenes bicincta*, which builds its clay cells on the walls of houses and stores them with spiders.

AN IMPROVISED CANOE—ONCE A SHEEP TROUGH.

The ants are the most ubiquitous living things in Australia, seeming able to thrive in even the driest localities. Forel records 85 species as known from South-West Australia, of which 37 are at present only recorded from that region. The largest species is that known as the Bulldog or Sergeant Ant (*Myrmecia vindex*), whose sting is very painful. This ant is interesting as a member of the most primitive genus of existing ants in which the workers can only be distinguished from the females by their slightly smaller size and by never possessing wings.

Coleoptera.

This order is extremely rich in species in South-West Australia, and the great majority of them are endemic. The families most largely represented are Carabidae, Scarabaeidae, Buprestidae, Tenebrionidae, Curculionidae, Cerambycidae and Chrysomelidae.

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Lepidoptera.

This order is chiefly remarkable for the paucity of butterflies. The only species that can be called common is *Pyrameis cardui kershawi*. The only families which contain species endemic in the region are the Lycaenidae and Hesperiidae, which together contain the bulk of the butterflies. Of Nymphalidae we have only six species, of Pieridae but two, and only one Papilio. All of these are forms which have a wide range over the southern part of the continent and several of them only occur sporadically in the south-west.

The place of butterflies is filled to some extent by the connecting-link Moths, Castniidae, for the species of Synemon are numerous and sometimes plentiful in individuals. There are also a number of Agaristidae which fly by day.

The Noctuidae and Geometridae are well represented. Perhaps the most interesting family of moths is the Psychidae, whose larvae live in silken sacks, to the outside of which most species attach bits of stick or leaf. The larvae of many of the Eupterotidae are social and construct great silken bags in the trees. Of the families of smaller moths, the Oecophoridae are the most numerous.

Diptera.

This group has been very little studied, though it comprises the three most troublesome pests of Australia, the mosquito, the bush-fly, and the sand-fly. March-flies, Tabanidae, are also disagreeably persistent at times in their unwelcome attentions. The most striking of our flies are contained in the family Asilidae, which comprises some giant forms two inches long and three across the

ROAD SCENE NEAR ARMADALE.

expanded wings. These Robber-flies fortunately prey on other insects. The Tachinidae are even more useful in this way as they lay their eggs on the living larvae of the cut-worms and other lepidopterous larvae ; they appear to be much more effective in keeping these pests in check in this country than are the hymenopterous parasites.

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Siphonaptera.

The fleas of Western Australia are very little known.

Hemiptera Heteroptera.

The bugs are another group of which our knowledge is at present very slight. Pentatomidae, Coreidae, Lygaeidae and Reduviidae are all well represented. Hydrometridae, Notonectidae and Corixidae are found in ponds and creeks, and a number of species of the first family occur on rock pools or near reefs along the coast.

Homoptera.

Cicadidae, Psyllidae and Coccidae are very well represented, whilst Cercopidae, Membracidae and Fulgoridae are not uncommon. Aphidae are only represented by certain introduced species, there being no native forms.

Cicadas, which are commonly known as locusts, are plentiful in the bush, and on still, hot days their continual screech becomes most irksome. The commonest large species is the white-banded *Henicopsaltria fullo*. Some of the larger Psyllids are very much like small Cicadas, other species produce lerp-scales on the foliage of gum-trees.

A TANK FED FROM NATURAL SPRINGS, NEWMARRACARRA.

Scale insects are very numerous and offer a great variety of forms, found on plants of every kind; moreover a large number of destructive species have been introduced with fruit trees and are the worst pests of the orchardists. The largest of our Coccids are the species of Mealy Bugs of the genus Callipappus.

Mallophaga.

These parasites are very common on most of our native animals and birds. They have not at present been studied by any worker in this State.

ARACHNIDA.

Scorpionidea.

Eight species of scorpion are at present known, only two of which are at all common. These are *Urodacus novaehollandiae*, a light-brown animal of moderate size found on the ground under logs, and *Lychas marmoreus*, a small slender species usually found under the bark of trees.

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Araneida.

Simon in the *Fauna Suduest Australieus* gives a list of all the Spiders at present known from Western Australia which records 230 species (including a small number of subspecies); of these 160 collected by the Hamburg Expedition were described as new, and 20 new genera had to be created. It must be supposed that most of these are peculiar to this State, which would point to nearly 70 per cent. of the species being endemic.

Simon states that the Aranean fauna of Western Australia has certain characteristics in common with those of other parts of the continent. Three genera have their nearest allies among South African and Malagasy forms. On the other hand we do not find in Western Australia the affinities to the Malayan fauna which are so numerous in Queensland.

Our largest spiders are members of the Lycosidae and Clubionidae, and are usually known as tarantulas; there are also very large trap-door spiders of the family Avicylariidae.

Chernetidia.

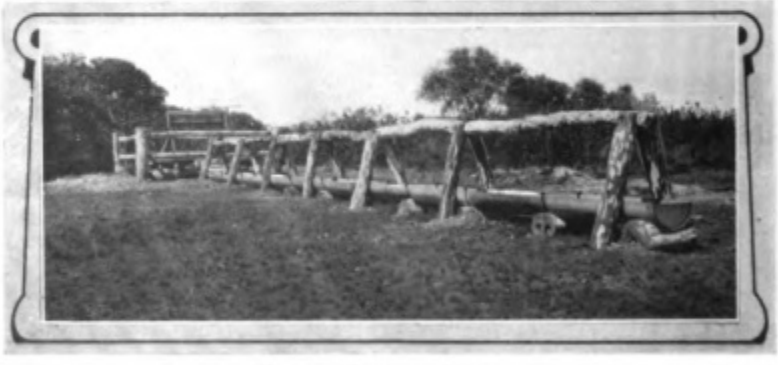
Pseudo-scorpions appear to be fairly plentiful, being frequently met with under stones and bark as well as among the leaves of Xanthorrhea, a haunt of many cryptozoic forms. Only three species are at present described, all of which are peculiar to the State.

Acarina.

Very little attention has been paid to the members of this order. Ticks of several species are among the pests of the bush, and most of the native mammals and some of the reptiles are infested with them.

MOLLUSCA.

The Mollusca are tolerably well known and a large report on the West Australian species has just been completed by Hedley of the Australian Museum, Sydney. It is impossible to make an abstract giving in a few lines any idea of the species recorded in the larger groups, especially the Gastropoda.



A STOCK WELL IN THE INTERIOR.

Very many of the familiar genera of the European coast are represented, but by different species. About 100 species of lamellibranchs at least have been recorded from the south-west. The large pearl oyster *Margaritifera* (*Pteria*) *maxima* does not extend so far south, but a small species is fished in Sharks Bay.

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Species of Pinna occur off Fremantle. Mytilus has been recorded from West Australia but the common member of the family is probably *Brachyodontes erosus*, which occurs on the rocks of the coast and the islands outside Fremantle.

Four species of Cardium are to be found in the Swan River. No species of Solen seem to have been found in the region.

A fresh water mussel, one of the Unionidae, is common in the rivers and occurs in very large numbers in Mundaring Weir lake—the species is *Diplodon ambiguus*, Philippi.

Another lamellibranch which forces itself upon the notice of the State is the Teredo. Thousands of pounds have been lost at Fremantle and Bunbury owing to the ravages of this pest. The hard jarrah piles are riddled away as if they were pine. Two species are known, *Nausithoria saulii* and *Nausithoria thoracites*.

Limpets are quite common on the rocks, and very large forms occur which remind one indeed of the Channel Islands at Home. *Patella neglecta* appears to be the common species, but five others at least occur. Haliotis abounds and is known locally as the Mutton Fish. The species *H. Roli* appears to be the most common.

Of the remaining gastropoda it is difficult to say anything. At the very least 350 species have been recorded from the South-West. Vermetus, sp., is responsible for great shelly tracts at Geraldton and the Abrolhos, and occurs also in considerable numbers near Fremantle. The Nudibranchs appear to be numerous and very brilliantly coloured, but little is at present known about the species. Of land shells, a common one to be certainly seen at Yallingup is *Bothriembryon kingii*.

The Cephalopoda do not seem to be very well known. Spirula shells abound on the sandy coasts; living specimens are conspicuous by their absence. Only one octopod has been named up to date, although other most certainly occur, and six species of sepiidae have been recorded.

SOUTH PERTH, FROM KING'S PARK.

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Polyplacophora.

Chitons are exceedingly numerous on the rocks of the coast. Two papers on these West Australian forms appeared about the same time. Torr collected 32 species between Albany and Fremantle and of these, a large majority, 23, were similar to South Australian forms. The Hamburg Expedition's collection contained 19 species, and came from Albany, Bunbury, Fremantle district, and Sharks' Bay. Thiele states that they were in general Indo-pacific forms, and no

ON THE SWAN RIVER.

relations to the antarctic species were to be found. It is curious indeed that only six species are common to the two lists! So far as our present knowledge goes, 45 species are known on the W.A. coast. The common species at Yallingup are *Liolophura georgiana*, *Ischnochiton cariosus*, *I. ustulatus*, *I. resplendens*, *Callistochiton antiquus* and *Chiton torrianus*.

ECHINODERMATA.

The *Crinoids* of South-West Australia are all unstalked forms. All the families are characteristically East Indian, and also the genera, except two, which are peculiar to Australia and are confined to the southern coasts of the island continent. About 20 species are known in the region under consideration; 31 are recorded from the West Coast. Clark states that in general facies the Australian crinoid fauna is an old fauna, the oldest found in the recent seas, having reached a stage of senescence far beyond that attained by the crinoid fauna of any other area.

The *Ophiuroids*, of which about 32 species are recorded from the South-West, almost all belong to the Indo-Pacific fauna. One or two forms which occur have a much wider distribution but give no particular character to the fauna. Two species are more peculiar—one of them (*Amphiura constricta*) having been only captured once before by the "Challenger" at Port Jackson, and the other, (*Ophiactis Lütkeni*) is known only from some individuals found at Fernando-Po.

About 18 species of Asteroidea are recorded for the district south of Sharks Bay (although this number is probably far short of the total number of species collected). Very few are known to exist out of the Australasian region.

A list of the Echinoidea collected by the West Australian Museum is now in the press and should be ready by the time of the meeting.

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VERMES.

The *Polychaeta* are practically unrecorded from the coasts of South-West Australia. A number of different species were collected at the Abrolhos Islands, but they have not yet been reported upon.

The *Oligochaeta* have been studied in detail by Michaelsen of Hamburg. Eighteen genera and 52 species are known from the district. Fluviatile oligochaeta are very rare, and the species recorded have a wide distribution.

The Marine and littoral species show no well-marked distinctions from known species. Thirty-four of the terrestrial species are endemic, but all the genera are to be found in other states of Australia. Michaelsen states that South-West Australia belongs to the Australian region of terrestrial Oligochaeta, and has no special character of its own nor nearer connections with the nearest extra-Australian districts than the Indo-Malayan and Ceylon districts.

COELENTERATA.

The distribution of the Colenterata down the coast shows very distinctly (so far as the species are at present known) the tropical nature of Sharks' Bay and northern regions, and the gradual disappearance of tropical species as one passes

HARVESTING THE CROP.

south. Reef corals occur in numbers in Sharks' Bay but do not appear to be reef-builders there. If this is correct real coral reefs do not occur anywhere on the coast of South-West Australia in the region under discussion, but are to be found on the Abrolhos islands much further south than Sharks' Bay and forty miles or so away from the coast. Species of Turbinaria, Pocillopora, Fungia, Madrepora, occur in Sharks' Bay. Fungia does not appear further south. Isolated colonies of Pocillopora are to be found on Rottnest and Garden Islands, opposite Fremantle, and a species of Turbinaria as far south as Bunbury (33° south Lat.)

Eighteen species of Actiniaria were obtained by the Hamburg Expedition, and of these, fifteen were recorded for the first time so that only three are of any use at present for purposes of geographical distribution. These three occur in the Torres Straits and at Thursday Island. There are undoubtedly many other species in the collection made last year at the Abrolhos Islands.

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A large number of Alcyonaria have been collected on the coast, almost all coming from Sharks' Bay. Many species belong to the family Nephthyidae, and are peculiar to the coast. Sarcophytum is well represented, the species occurring elsewhere on the coast of East Africa, the Maldives, Ceylon, Madagascar. Two Pennatulids only have been named and one of these has been recorded previously from the Nicobar Islands. Of the hydroids no records are to hand. A species of Sertularia is very common on Zostera along the coast.

SPONGES.

Dendy recognised a great similarity between the sponge fauna of Ceylon and that of Australia and the adjacent islands. The sponge fauna of the south-western region seems, however, to be very distinct, for most of the Tetraxonida collected by the Hamburg Expedition are new species, and the two or three which occur in Ceylon are to be found over a very great area. The coast is particularly rich in sponge species, but up to date very little recent systematic work has been published. Lendenfeld recorded about thirty species from Western Australia. Whitelegge records the following sponges of commercial value :—*Euspongia illawarra*, *Hippospongia equina*, *var. elastica*, and *H. equina var. meandriformis*, *Euspongia officinalis* is also to be found. There is perhaps good material for a sponge fishery. Papers have only been published on the *Tetraxonida* and fresh water sponges by the Hamburg Museum Expedition. Although ten fresh water sponges are known from Australia, only one has been found in West Australia. The species belongs to the genus *Ephydatia*, which occurs in the Eastern States. *Ephydatia multiformis* is peculiar to the State and was found in Herdsman's Lake —not much more than a swamp—in the vicinity of Perth.

QUEEN'S GARDENS, PERTH.

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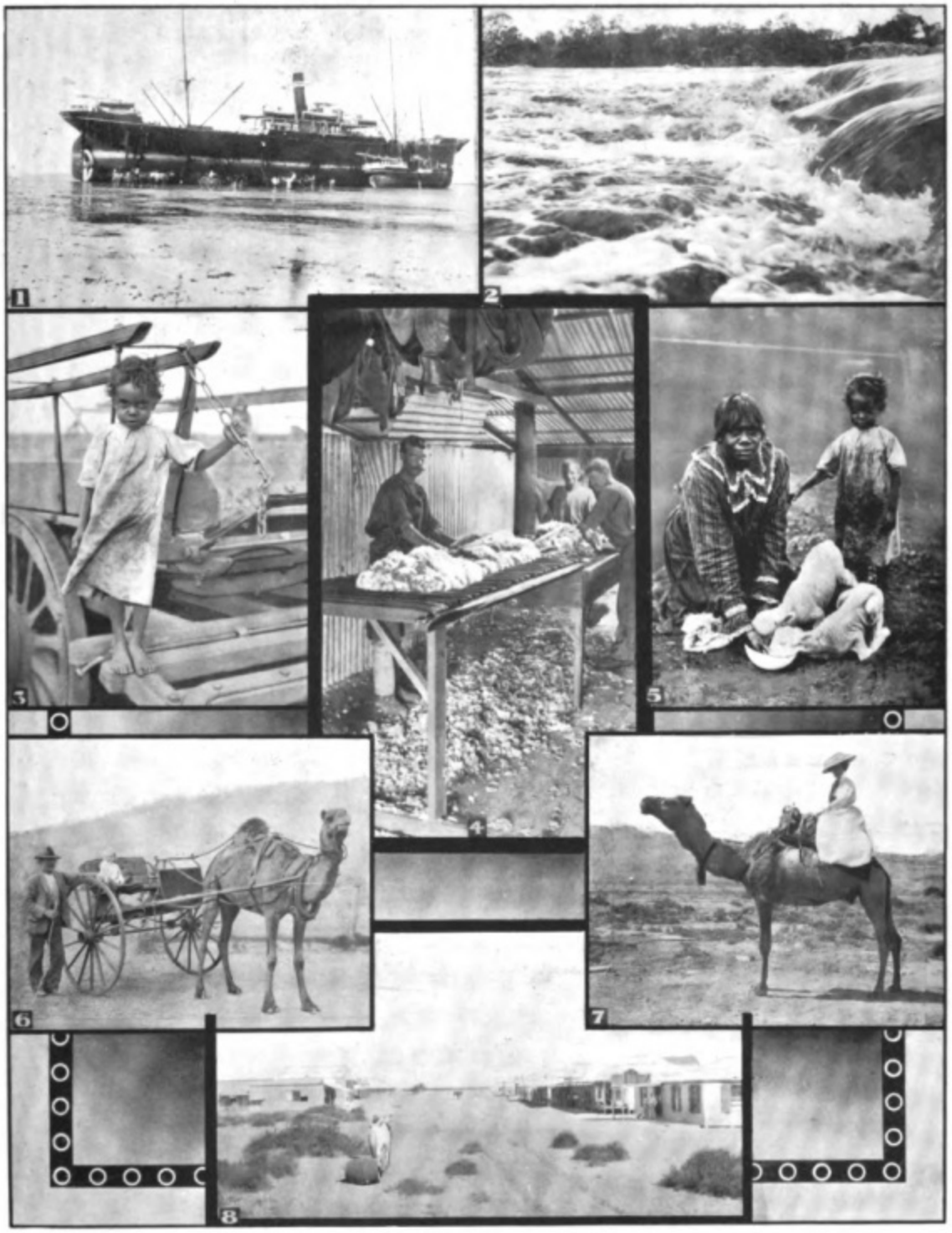

GLIMPSES OF THE NORTH-WEST.

1. WHEN THE TIDE IS LOW.
2. THE HARDING RIVER IN FLOOD.
3. THE STATION MASTER'S DAUGHTER.
4. A WOOLSHED IN THE TROPICS.
5. STUDY IN BLACK AND WHITE.
6. MORE USEFUL THAN HANDSOME.
7. A SHIP OF THE DESERT.
8. A COASTAL SETTLEMENT.

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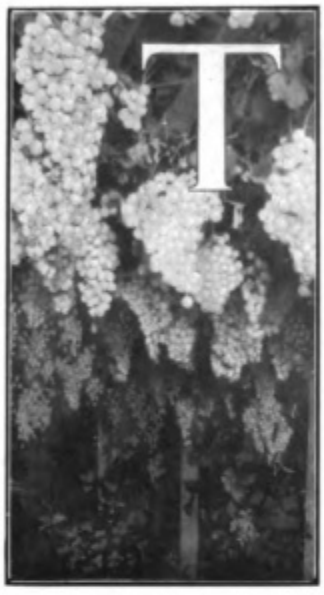
Zoological Gardens.*



THE Zoological Gardens, which Perth owes to the enterprise of the Hon. (now Sir) J. W. Hackett, are administered by the Acclimatisation Committee, consisting of six members originally appointed to superintend the acclimatisation of useful mammals, birds, and fishes, in Western Australia. The Gardens were established in May, 1897, when a director, Mr. E. A. Le Souef, was appointed and land granted in South Perth by the Government of the day. They were opened in October, 1898, and in the same month the Acclimatisation Committee was incorporated by Act of Parliament, and the land vested in that Committee for Zoological and Acclimatisation purposes, and for public resort and recreation.

The Hon. J. W. Hackett was appointed by the Government to the position of President, which he has held, practically without a break, ever since; during his absence in Europe, the Hon. W. Kingsmill has filled the post.

The Gardens have, since their inception, met with great success. The original idea was to provide three sections—for Zoology, Botany, and public recreation. This idea has been carried out, and the yearly attendances have ranged from 60,000 to 100,000; a result which, considering the smallness of the population of Perth, is most gratifying. The climate is well suited for stock: lions, tigers, leopards and black leopards have all been successfully bred and reared; monkeys, deer, antelopes, buffaloes, and various reptiles have shown the suitability of their environment by breeding freely; and among the birds successfully hatched may be mentioned ostriches, emus, cranes, white and black swans, rare geese, and many kinds of duck and waterfowl.

The Director gives periodical nature-study lectures to school children, who attend at reduced rates; and a further

ENTRANCE TO ZOOLOGICAL GARDENS.

* By E. A. Le Souef, Director Zoological Gardens.

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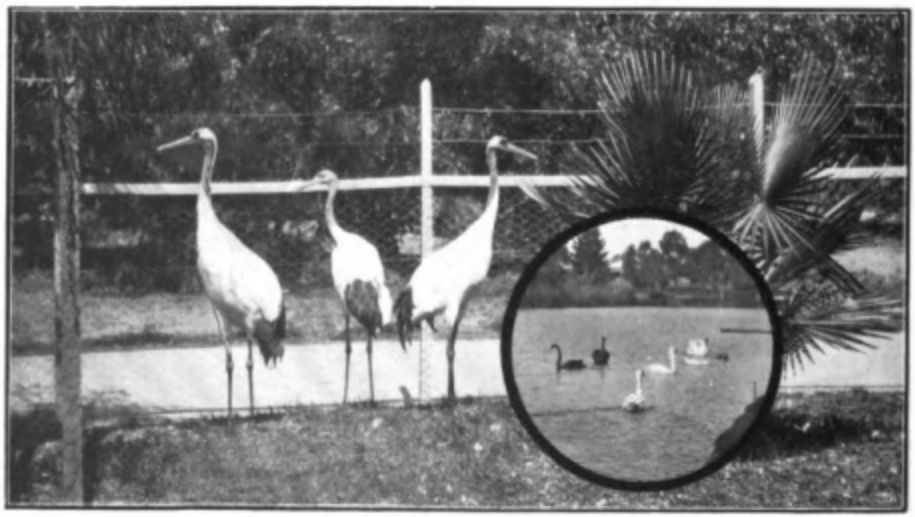
educational factor (introduced under Mr. Kingsmill's *régime*) is a system of educational camps, by which country children camp in the Gardens for a week at a time, and attend lectures kindly given by various gentlemen.

A splendid sports-ground, equipped for cricket, football, lawn tennis, and hockey, is included in the Gardens ; and an artesian bore, 1,865 feet deep, gives a good supply of hot water (103 degrees), which is suitable for watering plants, heating reptile houses, and also medicinal baths.

The Botanical section of the Gardens is very large, and the palms, in particular, form a beautiful feature. When funds permit, it is intended to make the Gardens more educative by a proper system of descriptive labelling, both for the Zoological and for the Botanical sections.



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The Western Australian Museum and Art Gallery.*

Historical Notes.

[1890].

THE GEOLOGICAL MUSEUM was established on its present site for the exhibition of the specimens collected by the Government Geologist, Mr. Henry Page Woodward, F.G.S., and his predecessors, and for the reception of the contents of the Fremantle Museum founded in 1881, by the Rev. C. G. Nicolay, the Registrar of Minerals, Mr. Bernard H. Woodward being appointed Curator.

[1891].

The Institution was constituted a separate department, under the control of the Hon. the Minister for Lands.

[1892].

Its scope was enlarged to include general Natural History and Ethnology and the title altered to the PERTH MUSEUM. The contents of the Museum of the Swan River Mechanics, founded by Capt. John Septimus Roe, R.N., in 1860, were purchased. These included Natural History, Ethnological and Art specimens.

[1895].

The Mineral Gallery was built, the collections having hitherto been displayed in the old Supreme Court, now the Ethnological Gallery. The control transferred to a Committee with Sir James G. Lee-Steere as Chairman. The collection of Paintings commenced.

[1897].

The James Street frontage was erected. The ground floor contains the Mammalian collections, the first floor the birds, and in the basement are stored the Reserve Collection of W. A. Birds, containing over 5,000 skins, the reserve Marsupials, the fish and the invertebrates in spirits. The present title was then adopted to show that the Institution was National and not merely local.

* By Bernard H. Woodward, F.G.S., C.M.Z.S., Director.

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[1908].

The Beaufort Street Wing was opened—the ground floor as a Sculpture Gallery and the first floor as a Picture Gallery.

The Natural History Collections contain almost complete collections of the Western Australian Vertebrate Fauna, and in addition, for educational purposes, a few typical specimens of orders not found in Australia.

The Australian palæontological collection contains an almost complete collection of W. A. Fossils, including a large number of types and a good general series of Australian fossil invertebrates, while, of the W. A. fossil vertebrates, every known species is represented, and several new species, as yet undescribed, discovered by Mr. Ludwig Glauert in the Mammoth Cave in the early part of this year.

The Ethnological Gallery contains a large and valuable collection of the weapons, etc., of the aborigines of this State.

[1911].

The Institution, by an Act of Parliament, placed under a Board of Trustees, and the Hon. Sir J. Winthrop Hackett, K.C.M.G., appointed President.

BLOOD BROOD MARES IN NATURAL GRASS.

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The Observatory.*

THE Perth Observatory was founded in 1896, and systematic transit work commenced in 1901. The adopted position for the transit circle is: Longitude 7h. 43m. 21·74s. E.; latitude 31 deg. 57m. 08·9s. S. The Observatory occupies a beautiful position on Mt. Eliza, 200 feet above the level of the Swan river, that skirts the base of the hill immediately west of and overlooking the city of Perth, and commands a splendid view, almost down to the horizon, all round.

Eighteen well-equipped observatories situated in different parts of the world are engaged upon producing a photographic star chart of the heavens. The work was started many years ago by some, and only recently by others—thus the Perth Observatory stepped into the gap left vacant by one of the South American observatories dropping out, and from 1903 the work has progressed, slowly at first, but recently at a more rapid rate, and now one-half of its share is about completed.

The work connected with this immense photographic catalogue of the sky is divided into two parts.

1 The preparation of meridian catalogues containing the positions of stars required for the subsequent reduction of the photographic plates, and

2. The taking of the plates and the measurement of all the star images thereon.

The measurement of the plates is performed by four ladies. The observations and publication of some 10,000 stars included in the meridian catalogues have been completed. So far as the meridian work is concerned it is proposed to confine it within the limits of 31 degrees and 41 degrees south declination.

The transit circle was made by Messrs. Troughton and Simms, and the Astrograph by Sir Howard Grubb, and are both erected in specially suitable

* By H. B. Curlewis, B.A., Acting Government Astronomer.

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buildings. The latitude and longitude of 13 special stations in different parts of the State have been determined by the Observatory. The reductions of the Fremantle and Port Hedland tides are being carried out at the Observatory.

Turning to the part the Observatory plays in the daily life of the State, we have the maintenance of correct time, which is of very great importance. The standard clock is regulated to keep true time of the one hundred and twentieth meridian (eight hours ahead of Greenwich) and by means of electricity performs the following functions : *a*. Dropping a time ball daily at 1 p.m. at Fremantle and at any other hour required by commanders of mail steamers, enabling them to rate their chronometers for the long run to Colombo, or for the shorter passage across the Great Australian Bight to Adelaide. *b*. Dropping a time-ball daily in Perth. *c*. Regulating the public clock at the Observatory gate. *d*. Controlling a parent clock at the Perth railway station, whence signals are communicated daily throughout the State railway system. *e*. Controlling two clocks in the telegraphic department, whence signals are transmitted to every telegraphic station throughout the State. *f*. Firing a time gun at the Observatory daily, and at Fremantle.

Five or six evenings a month are set apart for visitors to look through a special instrument provided for the purpose.

THE PERTH OBSERVATORY.

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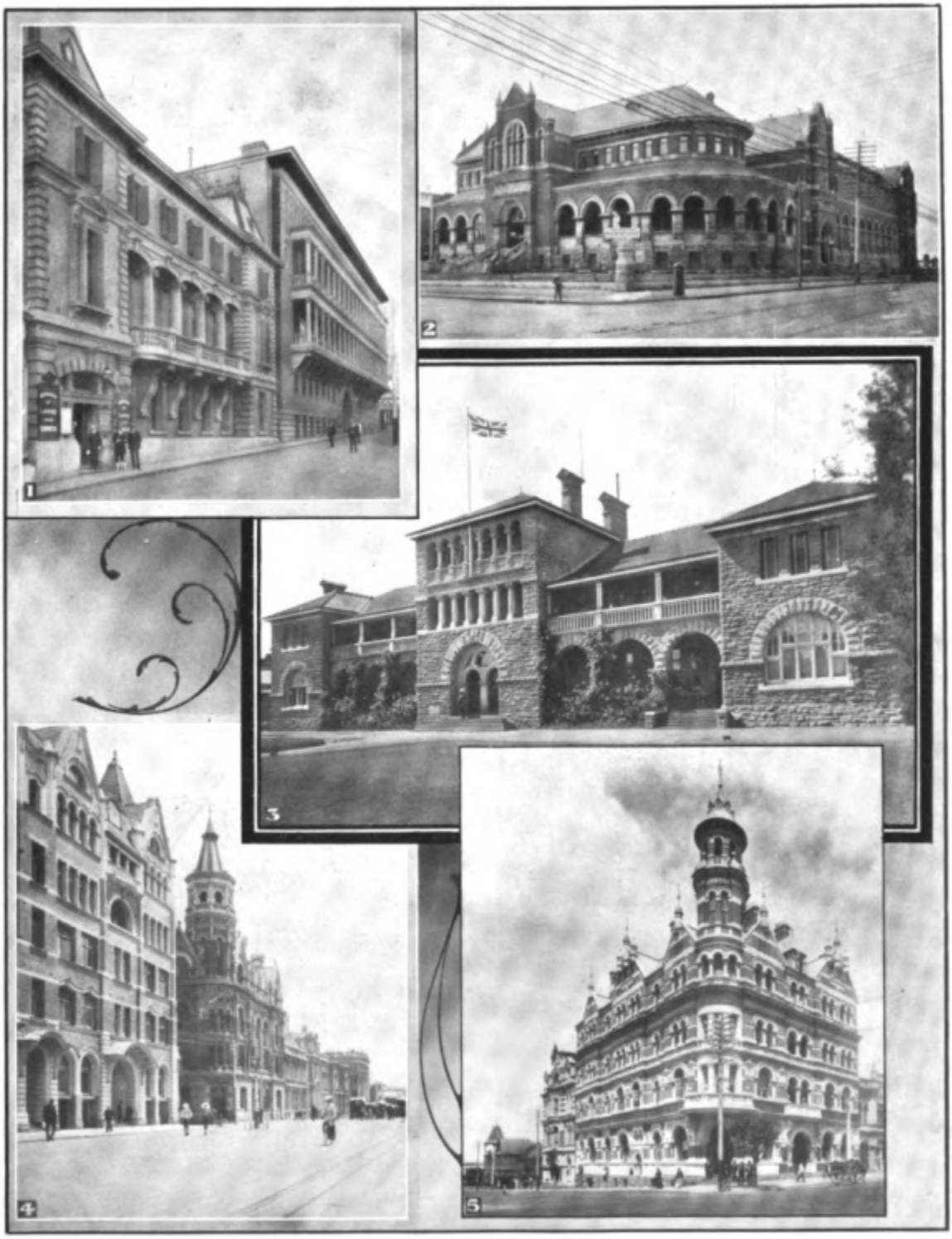

PERTH ARCHITECTURE.

1. SECTION OF GOVERNMENT OFFICES.
2. MUSEUM AND ART GALLERY.
3. THE ROYAL MINT.
4. EMANUEL BUILDINGS AND SURREY CHAMBERS.
5. T. AND G. CHAMBERS.

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British Association.

Western Australia, 1914.

1-2

Handbook and Guide

TO

Western Australia.

Prepared for the Members of the Advance Party of

The British Association for the Advancement of Science

on the occasion of their visit to Perth and the South-Western portion of the State, under the direction of the Local Publications Committee.

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