



Remarks on the Blood-vascular System of the Frog *Leiopelma hochstetteri* Fitzinger By Henryk Szarski, Department of Comparative Anatomy and Embryology, Copernicus University, Torun, Poland Communicated by Dr. K. A. Wodzicki [Read before the Wellington Branch, April 18, 1950; received by Editor, May 24, 1950.] Introduction The family Leiopelmidae* As pointed by Turbott (1942), the original spelling of the generic name is *Leiopelma*, not *Liopelma*. is considered by all recent authorities as the most primitive among the living Salientia (Noble, 1922, 1931; Slabbert and Maree, 1945; Millard, 1949, etc.). It has therefore several times attracted the attention of zoologists (Archey, 1922; Noble and Putnam, 1931; Wagner, 1934a, b; de Villiers, 1934a, b; de Vos, 1938–39a, b, etc.). Until recently, however, its vascular anatomy was completely unknown. Blood vessels are a very interesting and important part of amphibian anatomy and are at present being studied rather extensively (Bhaduri, 1930, 1931, 1938; Bhaduri and Ghose, 1943; Millard, 1941, 1942, 1945, 1949; Paterson, 1942; Szarski, 1937, 1948, etc.) with interesting results. I was therefore very glad to dissect some specimens of *Leiopelma* sent to me from New Zealand through the courtesy of Professor K. Wodzicki. When the work was already finished I learned that an account of the blood vessels of *Leiopelma* had been published by E. M. and N. G. Stephenson (1947). In the following notice therefore I do not attempt to give a full description of the vascular anatomy of that genus, especially as my material was very limited; I shall only discuss some details not observed by the Stephensons, or especially interesting when compared with other Salientians.

Material and Methods I had at my disposal three female specimens of *Leiopelma hochstetteri* Fitz., collected in a stream at Huia, Waitakere Ranges, Auckland, North Island, New Zealand, July 21, 1947, by Mr. E. G. Turbott. The animals were injected with Indian ink through the truncus arteriosus by Professor L. R. Richardson in Wellington. The dissections were performed under a low-power binocular microscope. In none of the animals were all the blood vessels completely filled with ink. Nevertheless, in all the specimens it was possible to examine the larger arteries and veins, and in one animal even the finer vessels were almost completely injected, especially in the region of the head and trunk.

Arteries The general plan is very similar to that found in the majority of Salientia (E. M. and N. G. Stephenson, Szarski, 1947), only a few points deserve special attention.

A. coeliaco-mesenterica is given off from the ventral aorta about 1 mm. caudad from the point of union of the right and left thoracic aortae, as in *Bombina*. A. mesenterica caudalis was present in all three animals investigated. The Stephensons give to this artery the name of the anterior haemorrhoidal. The middle sacral artery (aorta caudalis) was present in all specimens. The origin of this vessel is, however, different from that described in other species, as it does not branch from the abdominal aorta but from the right or left common ilia artery (Fig. 1). The Stephensons figured this vessel in their diagram of the arterial system (Plate 43), but did not, however, notice its homology with the caudal artery of the tadpole and adopted the name "posterior haemorrhoidal artery." Text Fig. 1. The branching off of

the middle sacral artery. A.caud., aorta caudalis; A.il.comm., a. ilica communis; A.mes.caud., a. mesenterica caudalis; Aor.ab., aorta abdominalis. As stressed by the Stephenson, the large cutaneous artery is a spacious vessel. Its diameter equals the diameter of the pulmonary artery. It runs in a cranio-dorsal direction, surrounds the scapula cranial and divides into three vessels very similar to those found in *Rana esculenta*, namely: ramus lateralis arteriae cutaneae magnae, r. auricularis a.c.m., and r. dorsalis a.c.m. R. lateralis a.c.m. corresponds to the continuation of the large cutaneous artery in *Bombina*, *Pelobates* and *Bufo* (Szarski, 1948). It runs caudad directly under the skin which it supplies. R. auricularis a.c.m. runs cranial exactly as in *Rana*, reaches the skull and bends in a curve ventrad, finally supplying the thymus and the muscles of the mandibular joint. It does not, however, anastomose with the temporal artery, as in *Rana* and *Bufo*. R. dorsalis runs dorsad as in *Rana*, and supplies the skin of the back and of the dorsal surface of the head. Veins As in other Salientians, the blood reaches the sinus venosus through three venae cavae, namely two v.v. cavae craniales and one v. cava

caudalis (Fig. 2). V. cava cranialis (V.cav.cr.) arises through the junction of the following vessels: v. jugularis externa (V.jug.ex.), v. jugularis interna (V.jug.int.), v. subscapularis (V.subsc.), v. cardinalis caudalis (V.card.caud.), and v. subclavia (V.subcl.). Text Fig. 2. The principal vessels of the trunk seen from the ventral side. Left side of the drawing: the arrangement found in specimens Nos. 1 and 2. Right side: specimen No. 3. A.coel.m., a. coeliaco-mesenterica; A.occ.vert., a. occipito-vertebralis; Aor., aorta thoracica; V.card.caud., v. cardinalis caudalis; V.cav.caud., v. cava caudalis; V.cav.cr., v. cava cranialis; V.jug.ex., v. jugularis externa; V.jug.int., v. jugularis interna, V.subcl., v. subclavia; V.subsc., v. subscapularis. V. jugularis externa arises from the union of the lingual and faciomandibular veins. The tributaries of the faciomandibular vein are peculiarly arranged. This detail was not mentioned by the Stephenson. They unite in the neighbourhood of the mandibular joint. The principal tributaries are: v. mandibularis interna, v. facialis, v. infratympanica, and a rather strong vessel conducting the blood from the floor of the mouth. V. mandibularis interna runs exactly as in other Salientians. V. facialis conducts the blood from the palate and from the skin of the lateral surface of the head (Fig. 3). One branch runs from the nasal region, directly under the skin to the caudal margin of the orbit. Here it is joined by another branch running immediately under the skin from the region of the mandibular joint in the cranial direction. The vein formed by the union of those branches crosses the maxillary

bone dorsally and reaches the palate, where it runs caudad on the internal margin of the maxillary. On the caudal margin of the palate, this vein [called v. facialis in spite of dubious homology (V.fac.)] is joined by a second vein from the palate, V. palatina (V.pal.). Then after a short course the facial opens into the faciomandibular vein. Text Fig. 3. Veins on the palate, seen from the ventral side. Max., maxillare; V.fac., v. facialis; V.pal., v. palatina. V. palatina conducts the blood from the palate in a manner not noticed in other Salientians. It arises under the medio-cranial region of the orbit by the union of two vessels: one running from the region of the choanae, the second from the lateral part of the palate. The palatine vein runs caudad, roughly parallel to the lateral margin of the parasphenoid, bends laterad, and in the region of the mandibular joint opens into the facial vein. V. infratympanica is a slender vessel which runs ventrad from the internal jugular to the external jugular in the temporal region. A tributary of the tympanic vein is v. thymica. From the above description it is obvious that the arrangement of veins in the palatine region in *Leiopelma* differs considerably from that found in the majority of Salientians. A similarity to this pattern is displayed only by *Bombina*, as in this animal the facial vein runs also on the internal surface of the maxillary (Szarski, 1948). V. jugularis interna begins as in other Salientia in the angle of the skull formed by the cerebral box and os prooticum in the vicinity of R. hyomandibularis nervi facialis, as v. cerebralis media. In *Leiopelma* it is a very slender vessel conducting little blood and difficult to detect in sections. According to the Stephenson it receives a tributary from the palate. In my material I could not verify this point. The course of v. jugularis interna follows the normal Salientian pattern. A very interesting detail is observed in the formation of the vertebral vein. This vessel is much stronger in *Leiopelma* than in

other Salientia. It drains the blood not only from the vertebral muscles but receives also a very strong tributary from the central nervous system. The last-named branch leaves the skull together with n. vagus. As the internal jugular is a slender vessel, the vertebral vein is in *Leiopelma* the principal route conducting the blood from the brain (V. cerebralis posterior). V. vertebralis opened to the internal jugular in specimens Nos. 1 and 2 (left side of Fig. 2). In specimen No. 3 the arrangement of the veins differed, as the vertebral vein opened not into the internal jugular but into the postcardinal vein (Fig. 2, right side). V. subscapularis and v. subclavia drain, as in other Salientia, the thoracic limb. The large cutaneous vein opens into v. subclavia similarly to all Salientians except *Bombina*, where two cutaneous veins exist, one opening into the subclavian and the other into the subscapular vein. The large cutaneous vein in *Leiopelma* drains the blood from the skin of the trunk, but as in the majority of Salientia, it does not reach the head region. In the thoracic limb only two transverse anastomoses were found. The first one runs on the upper arm directly under the skin, on the cranial margin of the leg, and connects v. branchialis with v. profunda brachii. The second anastomosis is formed by arcus venosus dorsalis manus in the region of the wrist. As first stated by the Stephenson, in *Leiopelma* the postcardinals persist in the adult state. This feature is shown among Salientia also by *Ascaphus*, *Bombina*, *Discoglossus* and occasionally in *Alytes* (Howes, 1888). V. v. cardinales caudales (Fig. 2, V.card.caud.) begin in *Leiopelma* in a tangle of vessels, forming spacious sinuses between the kidneys. They run cranio-laterad, along the mesial borders of the kidneys, parallel to the thoracic aortae (Aor.) and open into the precavals (V.cav.cr.). Also from the same venous sinuses arises the postcaval (V.cav. caud.) which is a very large vessel (diameter ca. 2.5 mm.). It follows the normal Salientian course. Blood vessels in the pelvic limb were in all three specimens rather poorly injected. It is therefore difficult to go into a detailed description. The principal vessels were, however, clearly visible. They follow closely the arrangement found previously in *Bombina* (Fig. 4): v. femoralis dorsalis and v. ischiadica are present and are united by an anastomosis on the lateral side of the knee joint. V. femoralis ventralis and v. ilica transversa are absent. The description given by the Stephenson of this region is too general to be considered here. It was impossible to ascertain the presence of the caudal vein. Finally, one peculiarity of the veins in *Leiopelma* should be emphasised. It is common in this species to find a vein duplicated by a second one, running parallel and uniting after a shorter or longer course. So, e.g., I met once with two parallel vertebral veins (spec. No. 3), once the internal jugular was duplicated on the right side of the body (spec. 2), and once the faciomandibular vein ran in the

form of three parallel vessels (spec. No. 2). This points to a great variability in the venous system, which can be considered as a primitive feature. A similar observation was made in *Pipa* (Klinckowström, 1894) and in several Caudata (Szarski, 1938). Text Fig. 4. Principal veins on the thigh in Salientia (after Szarski, 1948). P., *Pelobates*; Bo., *Bombina*; R., *Rana*; Bu., *Bufo*. A.isch., a. ischiadica;

V.fem.d., v. femoralis dorsalis; V.fem.v., v. femoralis ventralis; V.glut., v. glutea; V.isch., v. ischiadica. Discussion This short description of the principal points in the arrangement of the blood vessels of *Leiopelma* indicates that although several traits of its vascular anatomy are evidently primitive, in general, however, a great similarity exists in the organisation of this primitive animal and the majority of *Salientia*. When considered in detail the blood vessel system of *Leiopelma* is nearest to that of *Bombina*. This fact indicates a great primitiveness of *Discoglossidae* in general. Similar results were also obtained by comparison of the cranial morphology of those *Amphibians* (Slabbert and Maree, 1945). The following points of vascular anatomy should be especially stressed as common both to *Leiopelma* and *Bombina*: the origin of the a. coeliaco-mesenterica, the persistence in the adult animal of v. v. cardinales caudales, the course of the facial vein, the course of the venous anastomosis in the upper arm, the arrangement of the veins in the thigh. All those features are probably primitive and therefore indicate a great antiquity of *Leiopelma* and *Bombina*. Very important, also, is the fact that the structure of the great cutaneous artery in *Leiopelma* is closely similar to that found in higher *Salientia*. It suggests that the presence and characteristic anatomical relations of this vessel are a very ancient trait of *Salientia*. Cutaneous respiration was evidently developed long before *Salientia* began to split up into the groups living at present. Poor development of the great cutaneous artery which characterises the *Pipidae* must be regarded as a result of secondary adaptation to the watery habitat. As a primitive feature, present only in *Leiopelma*, we can consider the presence and large development in the adult of the v. cerebralis posterior. According to van Gelderen (1924, 1933) and Millard (1949) in the tadpole of *Rana* and *Xenopus*, three veins drain the cranial

cavity, namely v. cerebralis anterior, media and posterior. In all *Salientias* so far dissected v. cerebralis media remains the principal vessel of the brain. In *Xenopus*, v. cerebralis posterior persists in the adult state, but as a rudiment (Millard, 1949). In *Leiopelma* it is the principal vessel. Recently the vascular anatomy of *Xenopus* was an object of detailed study (Millard, 1941, 1942, 1945, 1949; Paterson, 1939, 1942). When compared with *Leiopelma* and *Bombina* it is striking how few points were found in *Xenopus* which could be considered as primitive, and how many are peculiar to this animal only, and are evidently extreme adaptations to life in water. It seems, therefore, that the present systematics of the lower *Salientia*, founded by Noble (1924, 1931)—(i.e., dividing those animals into two suborders: *Amphicoela*—including only one family, *Leiopelmidae*, and *Opisthocoela*—including two families, *Discoglossidae* and *Pipidae*)—cannot receive support from the angiological point of view. The *Discoglossidae* seem to be more closely related to the *Leiopelmidae* than to the *Pipidae*. Summary The arrangement of the principal arteries and veins was examined in three female specimens of *Leiopelma hochstetteri* Fitz. The principal findings are the strong development of the large cutaneous artery, the presence of postcardinals in adult specimens, the peculiar mode of origin of the facial and faciemandibular veins, the fact that the greater part of the blood from the brain leaves the skull through the vagus foramen and flows into the vertebral vein, and, finally, the presence in the thigh of v. ischiadica and v. femoralis dorsalis. These features, compared with the vascular anatomy of the other *Salientia*, suggest that: (1) Cutaneous respiration is a very ancient property of *Salientia*; (2) the *Leiopelmidae* and *Discoglossidae* are closely related; (3) the *Pipidae* is not a primitive group, but one secondarily adapted to life in water. Acknowledgments I am deeply obliged to Mr. Turbott and Professor Richardson for their kindness in providing me with material for this work, and also to Professor Wodzicki, who was so kind as to arrange the consignment of preserved animals to Poland. References Archey, G., 1922. The habitat and life history of *Liopelma hochstetteri*. Rec. Canterbury Mus., 2, pp. 59–71. Bhaduri, I. L., 1930. Notes on the arterial system of the common Indian toad, *Bufo melanostictus* Schneid. Journ. Proc. Asiatic Soc., 26, pp. 301–315. —, I. L., 1931. Observations on the course of the facial vein and the formation of the external jugular vein in some Indian frogs and toads. Journ. Proc. Asiatic Soc., 27, pp. 101–110. —, I. L., 1938. Observation on the course of the facial vein and the formation of the external jugular vein in an American bullfrog, *Rana catesbeiana*. Anat. Anz., 86, pp. 170–172. —, I. L., and Ghose, K. C., 1943. Notes on the lumbar veins in the common Indian toad, *Bufo melanostictus* Schneider. Journ. R. Asiatic Soc., 9, pp. 55–62.

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James Park James Park was born at Thanestone Hall in the Valley of the Don in the year 1857. His mother was a niece of Mountstuart Elphinstone, Governor of Bombay in the John Company days. We know very little of his youth except that he studied under Sir Andrew Ramsay, who was Professor of Geology at the Imperial College, London, and also Director of the Geological Survey of Great Britain. He can, however, have remained at his studies for not more than a year or so, but in this short time he acquired a passionate liking for geology. When, at the age of seventeen, he sailed for New Zealand he could not have dreamed that he was destined to play a pioneer role in working out the geology of that young Dominion. He actually left with his sister, who was sailing for Wellington to join her husband, an Army officer, but shortly after their arrival in New Zealand her husband was transferred to Gibraltar and James Park was left in New Zealand alone. He started work as a cadet on a sheep station near Castlepoint, but before doing so he presented to Dr. Hector, at the Colonial Museum, a letter of introduction from Sir Andrew Ramsay. The East Coast of the North Island was sparsely settled in those days and roads were non-existent. The spirit of adventure took him on long riding journeys and he became an inveterate huntsman after the wild cattle and pigs in which that country abounded: experience which was later to stand him in good stead on his pioneering expeditions in the King Country and the Southern Alpine regions. In those days, however, the price of wool fell so low that Park could see no future in sheep farming and in 1878 he returned to Wellington, where he obtained a junior position in the Geological Survey. His first geological expeditions were with Alexander McKay in the Nelson Province, followed, in 1879, by a geological and botanical expedition with McKay and Buchanan in the region extending from Lake Ohai to Hawea and Wanaka, with excursions to the sources of the Hopkins and the Matukituki. In 1880, he worked with Cox (who had been his cabin-mate on the clipper Soukar from Britain) in the Collingwood and North Auckland areas. That small band of now famous men who laid the foundations of our knowledge of the geology of New Zealand—McKay, Cox, Hutton and Hector—were all well known to Park. In his Memoirs, which have recently been presented to me by Mrs. Park (and which I am going to present to the Hocken Library) he paints pen pictures of these pioneers. Next to Hector, he states, McKay was the greatest exponent of New Zealand geology, and I would like to quote a few lines he has written about McKay, as it brings out not only McKay's character but also Park's ability with his pen: "Contrary to general belief, McKay was a man of high culture and wide reading. He was engrossed in legends and folklore and in the romantic years of old age lived in a fairyland of panelled rooms and mullioned windows hung with tapestry, a land peopled with Rob Roys, Robin Hoods, and Little Johns. His mind moved in two compartments—one devoted to the cold

facts of science, the other crowded with images of the past and tales of adventure. Scott and Burns he could recite with effortless fluency and dramatic effect. For the rest, Ossian appealed to his Celtic strain, and often he turned to Southey's version of Amadis of Gaul, a hero whose adventures and impossible triumphs gave him an unholy delight." Park also came to know Sir George Grey intimately, for, during sessions of Parliament, Sir George used to wander over to the Museum to inquire the fate of his cherished copper lode in Kawau Island. In 1882 Park left the Geological Survey to accept an appointment as computing draftsman in the Lands and Survey Department at Nelson, and in the following year he took the initial steps which led to the formation of the Nelson Philosophical Society. His restlessness in the drafting office and the urge to be among the mountains also led him to form the Alpine Club, from which the New Zealand Alpine Club has sprung. The membership at first was limited to eleven with Park as leader, and many arduous explorations were made among the mountains of Nelson and Marlborough, which brought to his mind Kipling's lines written in the foothills of the Himalayas: I remember lighting fires; I remember sitting by 'em; I remember seeing faces, hearing voices, through the smoke; I remember they were fancy—for I threw a stone to try 'em. "Something lost behind the Ranges" was the only word they spoke. The first ascent of Mount Franklin was made by Park, and he later successfully traversed the Mount Arthur Range, including the ascent of the summit—Double Peaks. It was not long before the tranquil atmosphere of the drafting office was too much for him, and in 1885 he rejoined the Geological Survey, working again with his cabin-mate, Cox, until the latter was appointed successor to Sir William LeNeve Foster as Professor of Mining at the Royal School of Mines. In succeeding years he was engaged on surveys in Taranaki (where he was able, for the first time, to place the succession of our Tertiary rocks on a sound basis), in the Collingwood area, and in the region of Big Bay and the Dart River on our West Coast. In 1886 and 1887 he conducted almost the first explorations in the King Country, which was in those days a refuge for disaffected natives and renegade pakehas, difficult of access and separated from the coastal areas by deeply dissected forest-clad ranges. He made the first ascent of Mount Ruapehu on January 8, 1885: the official narrative of the ascent is published in volume 19 of our Transactions. On June 10, 1886, when Park was in the Geological Survey office at Wellington, the Premier, Sir Robert Stout, came into the office with the tragic news of the Tarawera eruption, and within an hour Park had been despatched on the lighthouse steamer Hinemoa, which raced at full speed to Tauranga, reaching there on June 11. It is interesting to note that Park records that the decks of the vessel were covered with ash on rounding East Cape. By seven in the evening on the 11th he reached Rotorua by special coach. In his own words: "On mounting the erest overlooking Rotorua, suddenly there burst before us a panoramic view of the whole region that had

been riven and overwhelmed by the catastrophic outburst of the day before. Intense volcanic activity still prevailed from Tarawera far to the south, and a dense column of steam rose heavenward from the site formerly occupied by Lake Rotomahana." The following year saw him in the inaccessible Red Hill country of South Westland, which he reached from Glenorchy, ascending Mount Cosmos on the way, and then again he spent a summer in his beloved mountains of western Nelson. He did, in fact, write more than thirty official reports on many phases of geology for the Geological Survey. In 1889, after fifteen years spent in the exploratory work he so loved, and at the age of thirty-two, he was appointed Director of the Thames School of Mines at a time when the Hauraki goldfield had developed into one of the world's more important centres of gold-mining. This was a turning point in Park's career, because, although he retained his love for the mountains and returned to them whenever he could, he transferred his main interests to mining and mining geology and, later, to academic work. For a time he became Consultant to a financial organization with mining interests on the Hauraki goldfields, and in 1901 he accepted the Chair of Mining at Otago University, which had been rendered vacant by the accidental death of Professor Ulrich. Many men who were later to become famous passed through Park's hands. They include that group of mining engineers who were associated with Herbert Hoover (later President of the United States) in the Western Australian goldfields—Malcolm Maclaren, who became the world's leading mining geologist; John Agnew, who became the world's leading gold financier; G. W. Thomson, who became General Manager of the rich Ashanti mines; and several others. Park already had a very wide knowledge of the geology of New

Zealand and he did not allow this to stagnate after his appointment to Otago. During the years of his professorship he wrote five large memoirs for the Geological Survey, including three on Central Otago—the scene of so much successful alluvial gold mining. But the one which we in Dunedin know best is that dealing with the Oamaru District, which is still fundamentally correct. Park also became one of the best-known writers of mining engineering text books of his days, and in this connection his interests were exceptionally versatile. His first venture was a volume on the Cyanide Process of Gold Extraction, published in 1894. His practical experience on the Hauraki goldfields and at the School of Mines, where this process was developed, made this a particularly welcome volume and contributed much to his subsequent success in training mining engineers. This was followed by “Practical Assaying,” “Theodolite Surveying and Levelling,” “Mining Geology,” “Practical Hydraulics,” and “Textbook of Geology,” all of which were published in London, two were translated into German, and in all they ran into thirty-two editions. In 1910 he also wrote “The Geology of New Zealand,” which was published in this country. This well documented and most useful book gave his interpretation of the work of the older school of New Zealand geologists up to that date, and

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in some measure marks the close of a chapter, since the specialized work of succeeding decades, particularly in palaeontology, petrology and geomorphology naturally has called for some modification of the stratigraphical classifications and certain other conclusions of our great pioneer geologists. His writings were not, however, confined to official reports and text books. He was a contributor to many geological and some mining engineering papers and technical journals. The full list of his varied writings would contain about a hundred titles. He found time to go abroad, and travelled widely in the Western Australian goldfields, in Tasmania, and on the Continent, and he was engaged as a consultant in countries as far removed as New Caledonia and Spain. During the first world war, he reported on nickel, chrome, wolfram and molybdenite mines for the Allies in the Pacific region. Park retired at the age of seventy-five in 1931 and was appointed Emeritus Professor of Otago University. He had brought to the University a wealth of experience as an explorer, a fundamental knowledge of geology gained from Hector, McKay, and Cox, a knowledge of mining and mining geology from the Hauraki goldfields, and, above all, a knowledge of men and their ways. He belonged to the old school before the days of specialization and had an exceptional range of interests and an exceptional capacity for work. He served as President of the Otago Institute, and for many years was its representative on the Board of Governors of the New Zealand Institute. For fifteen years he was President of the Otago University Rugby Football Club, and he was also President of the New Zealand Society of Mining Engineers. He was a Fellow of the Geological Society, an Honorary Member of the Geological Society of Berlin, and an Honorary Member of the Institution of Mining and Metallurgy (London). His retentive memory, his sense of humour, and his never failing optimism made him a delightful conversationalist and an agreeable companion. He loved to entertain his students (and this I might say he did on a most lavish scale) and recount to them the stories of his exploring days; he kept young by his associations with the younger generation. He had a large family and his youngest son later became famous—he is Air Marshal Sir Keith Park, who controlled the Battle of Britain and then became the air defender of Malta, and later the Allied Air-Commander in Chief, South-East Asia Command. Park died at Oamaru in 1947 at the age of ninety, shortly after he had been visited by Sir Keith and Lady Park. His life of exceptional fullness and usefulness was crowned by the visit of his famous son, the anticipation of which had sustained him through the last months of illness. Professor Park's portrait hangs in the Scottish National Gallery among those of other distinguished Scotsmen, and a photograph of this portrait is published in this volume. G. J. W.

Patrick Marshall Dr. Patrick Marshall was for over forty years an outstanding figure among New Zealand scientists, and was well known to geologists in many lands as a very versatile and productive investigator. Born in 1869, he was the son of the Rev. J. H. Marshall, M.A., of Sapiston, Suffolk, who, chiefly for reasons of health, brought his family to New Zealand in 1876, and settled at Kaiteriteri in the Nelson District. He died, however, in 1878, and his widow and family went back to England, where Patrick Marshall entered school in Bury St. Edmunds. In 1881 his family returned to New Zealand and resided at Wanganui, and in the Collegiate School there Patrick Marshall completed his secondary education. He entered Canterbury University College in 1889 and in 1892 gained the B.A. and B.Sc. degrees with the Senior Scholarship in Geology which he had studied under Professor F. W. Hutton, F.R.S. In the following year he completed with high honours the M.A. course in Geology, working at the University of Otago under Professor G. A. F. Ulrich, completing his first research, a study of the Tridymite Trachyte of Lyttelton, which was published in 1894. Appointed Lecturer in Natural Science at Lincoln Agricultural College in 1893, his researches for a time were devoted chiefly to entomology. The writer is indebted to Dr. David Miller for the following note on Dr. Marshall's work in this field: “Marshall and Hutton were the New Zealand pioneers on the study of our Diptera... Marshall took up the study of two very difficult families of the Diptera, the Mycetophilidae and the Cecidomyiidae. He described some sixty-one species, which have stood the test of time except for the names of six of them, three of which were preoccupied in other parts of the world, and three were synonyms of his own species, a remarkable record when one considers that Marshall worked isolated from literature and colleagues specialising in these families. His three papers on the Diptera were published in the Transactions of the New Zealand Institute for 1896 (Vol. 28) together with a fourth, a record of a migrant butterfly. His interests in Biology were maintained after he took up Geology as a profession, and we find him presenting a discussion on the “Effect of the Introduction of Exotic Plants and Animals into New Zealand” to the Fifth Pacific Science Congress in 1933, which was published in its Proceedings.” In 1896 he became Science Master at the Grammar School, Auckland, and resuming his interests in geological research, he studied the volcanic rocks of that region, completing a thesis, the majority of which is still unpublished, for which he was granted the D.Sc. degree. In 1901 he became Lecturer-in-charge of the Department of Geology in the University of Otago and was elected Professor of Geology and Mineralogy there in 1908. Here he remained for sixteen years, a period of great activity in many directions. His physical strength which had been displayed by his successes on the football and cricket fields and on the tennis court, was now exercised in field geology and mountaineering. He was a very vigorous and successful teacher, active in University administration, both in the University of Otago and in

the University of New Zealand, of the Senate of which he was for some years a member. His list of publications during the period contains over fifty titles. They included a book on the Geography of New Zealand (1905, revised 1911), the Geology of New Zealand (1912), and the portions of the “Handbuch der Regionalen Geologie” dealing with New Zealand and the adjacent Islands, and with

Oceania (1912). He was extremely active in research. His accounts of the Geology of the Dunedin District (1906) and "The Sequence of Lavas at North Head, Otago Harbour" (1914), which involved a great amount of field work, and petrographical and chemical study, are among the most notable of his many papers. With them there are also to be recalled many other papers on the igneous rocks and other features of New Zealand geology in both the South and North Islands. His petrographic interests were extended to deal with the volcanic rocks of the south-western Pacific, and on this ground of mutual interest he entered into frequent correspondence and later personal association with Professor A. Lacroix, and was in 1938 elected a Correspondent de l'Academie des Sciences Coloniales. His active membership in what is now the Australian and New Zealand Association for the Advancement of Science gave him occasion to discuss before it the distribution of the igneous rocks in New Zealand (1907), Ocean Contours and Earth Movements in the South-West Pacific (1909), and his Presidential Address to the Geological Section on the structural boundaries of the south-western Pacific (1911) which were shown to be related to the line separating the regions wherein andesitic lavas occur from those wherein there are basic alkaline lavas. This concept was crystallised in his use of the term "the andesitic line" for the structural boundary of the western half of the Pacific basin in his account of the Geology of Oceania (1912), a term which has come into very general use, though an alternative term, "the Marshall line" has also been used with the same significance. The many problems, geophysical, geological, and biological arising from a consideration of the natural history of the Pacific were often in Dr. Marshall's mind, and formed the subjects of his Presidential Address to the Geographical Section of the Australian and New Zealand Association for the Advancement of Science in 1932, and that given by him as President of the whole Association in 1946. The preparation of his books on the Geology of New Zealand must have brought very vividly before him the unsatisfactory and to some extent contradictory conceptions regarding the stratigraphy of New Zealand during the opening decade of this century, and he devoted much effort towards the study of the sedimentary succession and molluscan faunas of the Tertiary and Cretaceous rocks, on which he wrote a number of papers, several of them in collaboration with Mr. R. Murdoch. The most important of these papers was his elaborate study of the Cretaceous ammonites of New Zealand (1926), in part written by him while in the British Museum of Natural History. In this paper the Indo-Pacific affinities of the New Zealand forms are discussed. In connection with the Geological Survey he wrote the portions of the Dun Mountain Bulletin (No. 12, published 1912) dealing with Mesozoic stratigraphy and igneous rocks, also the Tuapeka Bulletin (No. 19, published 1918).

Leaving the University of Otago in 1917, he became Headmaster of his old school, Wanganui College, and retiring from this after several years of service, he devoted himself for a time to geological research in the Pacific Islands and elsewhere, dealing with their petrology and the features of coral reefs. In 1924 he was appointed Geologist and Petrologist to the Department of Public Works, where in addition to his general consultative work, he carried out several major lines of research resulting in important publications, a study of special local interest on the building stones of New Zealand (1929) and two of more widespread theoretical importance. In his investigation of the Wearing of Beach Gravels and Beach Gravels and Sands (1928, 9), carried out both in the field and experimentally, he considered the change in the size and form of the pebbles and the amount and nature of the fine-grained or even colloidal material produced during the processes of attrition, impact and grinding, and in so doing threw much light on the conditions of origin of littoral and off-shore sediments. He also made (1935) elaborate studies of the rocks of rhyolitic composition which are widespread in the centre of the North Island of New Zealand and were originally thought to be flows and tuffs. He concluded that they were largely composed of particles which had been explosively erupted and had emitted incandescent gases until they had become on cooling agglutinated into coherent rock-masses often showing marked columnar jointing. This mode of origin is comparable with that of the material derived from nuées ardentes of Katmaian eruptions. The occurrence of rocks of like origin is becoming recognised in regions around the Pacific, and the term "ignimbrite" suggested for them by Marshall is tending to replace the term "welded tuffs" which was often assigned to them. In later years Dr. Marshall was greatly interested in the occurrence of orbicular granites in New Zealand, and gave a number of excellent polished specimens of these to geological museums, but published little thereon. He was active in the study of zeolitic minerals, believed by him to be of primary origin, occurring in volcanic rocks, especially in more or less alkaline lavas, and spent much time investigating various methods of recognising the presence and determining the nature of such minerals by their diagnostic reactions with various solutions principally of silver nitrate. His latest paper (1946), which gave a short account of such studies, was said to be the precursor of a more detailed study then in preparation, which unfortunately was never completed. Dr. Marshall's activities in connection with the Australian and New Zealand Association for the Advancement of Science, his presence at the meetings of the Pacific Science Congress in a number of lands, Japan, Java, and California as well as in Australia and New Zealand, and his presence at two European meetings of the International Geological Conference, as well as his many writings, made him well known to geologists in many parts of the world. His chief services to scientific societies were, however, given to the Royal Society of New Zealand, of which he was President in 1925-6, and from which he received the Hutton and Hector Memorial Medals. As an active member of its Executive Committee for many years he exercised much influence on its policy.

Patrick Marshall

The latest of the honours accorded to him in recognition of his long life of varied service to science was the Honorary Doctorate of Science conferred on him by the University of New Zealand in 1948, nearly fifty years after he had received the degree by examination on the grounds of his first major research in Geology. His interest in research was maintained to the last. In a letter to the writer sent in October, 1950, he referred to the interesting carbonate-bearing magnesian rocks near Milford Sound, which he had described in 1904, regretting that he was unable to return to the field and laboratory investigations of their problematical origin. But he passed away early in November in the eighty-second year of his age. W. N. B.

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Working

The Royal Society (known as the New Zealand Institute before 1933) was established in 1867 to co-ordinate and assist the activities of a number of regional research societies including the Auckland Institute, the Wellington Philosophical Society and the Otago Institute. These societies often did not have the means to publish the papers that were presented to them or maintain a written record of their activities. The NZ Institute was set up to remedy this through the publication of a single volume of transactions and proceedings on their behalf. This project has been carried out by the National Before 1933 the society was called the New Zealand Institute, and the journal's name was Transactions and Proceedings of the New Zealand Institute. It was active between 1868 and 1969 and was the most important scientific journal in New Zealand.[1]. Notable contributors. James Hector, geologist. William Colenso, botanist. Harold John Finlay palaeontologist and conchologist. Charles Fleming, ornithologist and palaeontologist. Thomas Hocken, botanist and anthropologist. Ernest Rutherford, chemist and physicist, Nobel laureate. The Royal Society was established in 1867 to co-ordinate and assist the activities of a number of regional research societies including the Auckland Institute, the Wellington Philosophical Society and the Otago Institute. The NZ Institute was set up to publish their papers in a single volume of transactions and proceedings. Access. Free. Date range. 1868-1961. No. of licences. Multi-user. Campus range. Whitcombe, C. D., 1872. Art. VIII.—On the Reclamation of Land devastated by the Encroachment of Sand. In: Transactions and Proceedings of the Royal Society of New Zealand 1868-1961, Volume 5. Web. http://rsnz.natlib.govt.nz/volume/rsnz_05/rsnz_05_00_000650.html. Citation key. Whitcombe, 1872. Datasheets. Jerusalem artichoke (*Helianthus tuberosus*).