

## **Supplementary Material**

### **George Adrian Horridge (1927–2024)**

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George Adrian Horridge autobiography notes 1986

26. June  
1986.

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To Librarian. R.S.

Hopefully this  
is not the final  
version (if I'm  
spared) but you  
might as well  
have it safe.

Att

Editorial Board

90/6 pm

George Adrian Horridge was the only child of George William Horridge, only son of George Washington Horridge who had a brother called uncle Punks, nobody knew why. Adrian's mother was Olive Stray who ran away, forty miles in a day. When she came back she got a smack, right on her ta-ra-bum-dee-ay! Olive was one of five daughters, and the Stray family had sweet shops in Sheffield, with a daughter serving in each shop in the nineteen-twenties. She was married to Billy (GWH) in 1925 and produced her son in Dec 1927, vowing never to have another because "she nearly died". The Horridge side in the eighteenth century originated from Lancashire and were related to Judge Horridge, famous for divorce law cases. There were other Horridges in Manchester and Liverpool but it is a rare name. The Sheffield branch were handle makers to the cutlery trade, cutters of horn, buffalo, stag, ivory and turtle shell, with side-lines in ivory and bone dust for special soups. A large proportion of the horn handles of game-carving knives made in Sheffield in the nineteenth century originated in their Pool factory, until new materials - the early plastics like xylonite and celluloid - came into use for handles and piano keys. Carved horn walking-stick handles and fancy scales for penknives were a speciality and asthma was the occupational hazard for those who worked among the organic dust of the horn. The horn factory was sold to become a picture palace in 1922 when it became clear that the business was ruined by too many non-working aunts and uncles who took a share of the profits, when plastic moulding was driving out the old methods, and when the inner city land became too valuable. George William (Billy) was absorbed by motor bikes in 1919; he raced on a flat-twin Douglas and began to buy second-hand motorbikes, do them up and sell them, working from home in the posh suburb of Ecclesall. The family had always lived at that end of the town, moving out from Sharrow Vale Road in the early years of the century, to Hunter's Bar and then to Dunkeld Road, Tullibardine Road and Caterknowle Road, all within a mile or two. About 1922 Billy founded a partnership in a motor cycle business with Reg Wildegoose (who was brother-in-law to the future Sir Fred Dainton FRS). About 4 generations of Horridge had been to King Edward VII School. George Washington was taken to school in a coach-and-four with a footman. When Adrian first went to that school in 1936 there were four masters who remembered his father being there, among them Toby Saville and Old Nicholas, both very free with the cane.

It was a time when the suburb's children, the family outing by car, the picture palace, the zoo man on the radio, sledging in January, conkers in autumn, bicycles, and scouring the woods along the western margin of Sheffield, were all formative factors for an intelligent, active, and strong boy. He was never at home; he was blessed with a loving mother who grumbled a lot, and a father who knew about tools, engines, woodwork, fixing things, meccano, electricity and flying kites. Family holidays were always at the same boarding houses at the same seaside resorts, Scarborough, Bridlington in Yorkshire and Mundesley in Norfolk. They never stayed in a hotel. The streak of independence was fostered by joining the school Scouts at the outbreak of the world war in 1940 at the age of 12. The war regulations put a stop to holidays by the sea, the coasts were closed, petrol was rationed and many things like toys became scarce. But the war had little effect on the enjoyment of life for independent boys who had bicycles and an inclination to camp out.

Ecclesall at the western edge of Sheffield was close to the moors leading up to Fox House Inn, Baslow, Ringinglow and Stanage, with the Hope Valley and the Baslow Valley over the other side. All that was gateway to the Peak District, Bakewell, Matlock, Eyam. Tideswell and Castleton. During the war this area was a marvellous stamping ground. Every holiday, and many week-ends the lads were out, often camping, sleeping in barns, later caving and youth-hostelling at next to no cost. Every hedge-hidden track, every walled field good for mushrooms, every conker tree, trout stream full of crayfish, ponds for newts and water beetles, camping ground by public stretches of the Derwent, every gritstone edge was explored. At the age of 13 he went with young Thompson for 6 weeks by bike, cycling round England as far as Cheddar Gorge. The scout uniform legalised and channeled boys who would otherwise have been indistinguishable from the rough lads from Sheffield who came by train into Derbyshire through the Totley rail tunnel. At Easter and all summer there were longer camps in North Wales and the Lake District, and farming camps for pea-picking in Bedfordshire. At first Adrian took his scout patrol, always as the leader, reserved but always knowing his own mind and relying on his own judgement. Then at the larger fixed camps he was quartermaster, managing the catering, and finally when about 17 he shook himself loose from the scouts and went solo. The reason was really the motor bike. The only son of a motor cycle dealer gets a bike as an advertisement, but this one never stayed in sight of home base.

School was a laugh: during the war for weeks at a time, King Edward III School was converted to a reception centre for bombed out families and Adrian had to turn up as a Scout to help. For months, school was held for half-days only in private houses, and the masters were called up. Even when there was school it was still a laugh for a boy who hardly ever did any homework at home and never worried about schoolwork because it came so easily.

The method of survival at school was to learn French vocabulary for the first lesson instead of singing the hymn in prayers, because you couldn't swot it up on the bus if you came by bicycle at the last second. Then, in the first lesson you did the homework for the second lesson and so on. The method depended on speed and a sort of animal ability to avoid danger. In any subject it was possible to be top of the form by working for the exam, which meant reading the book. Success depended on a perfect visual memory and a rational mind that did not miss a logical argument. In the schoolboy this facility developed into an encyclopaedic mind with a huge store of knowledge from books from the Sheffield Public library and the school library, none of it fiction.

The night before he left for the Cambridge scholarship examination, Adrian went to the youth club dance and had spent days previously exploring Derbyshire - but he won a Major Scholarship at St Johns College. While he was waiting to be interviewed by the chemist Dr Kipping, who was later a superfluous supervisor, he looked at a collection of terpenes on Kipping's window sill and in the interview commented on their stereochemistry from memory. This, of course, was the result of an abiding passion for chemistry, mostly learnt from tomes from the library read on camping trips. Also, a friend "Mousey Thompson" had for years collaborated on experiments with chemicals over a gas in the kitchen at home, as well as making full use of the school chemistry labs. The form room for the lower sixth was the chemistry lecture room with the preparation room opening off it. Plenty of nitrogen tri-iodide was made there, with lots of fireworks, nitrocellulose, bromo-acetone, diazo-dyes and methylene blue in the last couple of years at school. That was before it was realized that diaminodiphenyl and the naphthylamines might be carcinogenic for school boys. The masters had no idea what went on, but several boys who were self-motivated had a splendid education.

Cambridge was heaven in 1946. The batch of 10% of schoolboys who were admitted were almost all youthful green scholars, outnumbered by 90% of men back from the war. It was a time for hope, determination, return to work, building, new research and endless stories from the war. The Colleges were crowded, some married students were the first "squatters". As a result of meat shortages, an oriental restaurant in St John's Street was summonsed more than once for serving cat and dog as goat or rabbit. Life was frenzied and characters abounded. Adrian's first year rooms in M2 Second Court, shared with Derek Lennon were immediately under those of the Chaplain, Noel Dickworth, just returned from Japan POW camp. After a hard day, coaching the College boats on the river, Noel (a former Jesus blue as cox) would slump down on their sofa for tea or beer and talk on nothing but christianity or rowing. Others were more eclectic. That year most of the convenient ground-floor sets of rooms were used as drop-in points for students living out of college, one nameless individual seemed to have spent the war selling RAF petrol to rajahs in India, another had been with the independent armies in Greece, another was yellow from working in a cordite factory, another had had four ships sunk under him, another had parachuted into Germany to spend the rest of the war in Spandau. It became a habit to run between meetings, between lectures, from a foreign film at the Arts Theatre to a mountaineering club meeting. Breakfast meetings were organised by Martin Charlesworth, the President of St John's, for anyone in Second Court on one day, for people called Martin on another. Lectures began at 9 and sometimes there was a 5 o'clock seminar six days a week, with four supervisions a week, often with work to prepare for each. That was the result of taking four subjects, Biochemistry, Chemistry, Physiology and Zoology. Baldwin, tall bearded and gaunt as an Orthodox priest, held the audience in Biochemistry; Marshall, Rushton, Adrian, Willmer, lectured in Physiology, Gray, Ramsay Pryor in Zoology, Saunders and Kipping in Organic Chemistry. In fact a galaxy of excellent lecturers - if you had time to go. A lot of time was saved because Adrian found he didn't have to go to Chemistry lectures at all except occasionally to keep an eye on the level of detail, and he still got a 1st in the exam. His tutor, Colin Bertram, fresh back from the Middle East and not yet Director of the Scott Polar Research Institute, had deflected Adrian from chemistry towards the biological sciences, willingly as it happened because chemistry was cut and dried, and seemed to be a technological subject done in

chemical factories or laboratories which were uncongenial to a boy from the open air. It was all very well to read up the synthesis of dyes while lying in a tent under Great Gable; it would be quite a different matter as a life's work, hence the side step. The summers of 1947-48 were spent in the West of Ireland, and exploring the West Highlands, climbing in Skye from Glenbrittle, camping in Coriusk with new friends from other Colleges in the Mountaineering Club. That was the beginning of close friendships with Brian Ridley (later Professor in Nuclear Physics at Boulder, Col.), John Kay (later Professor of Nuclear Power at Imperial College and a Director of British Steel), John Young, Kim Smith, David Smith, and especially John Vaisey, a civil engineer. Within a year or two, these last four were all killed climbing and the shock of John Vaisey's death above Zermatt was particularly painful as can be seen from the obituary that Adrian wrote in the Cambridge Mountaineering Club Journal at the age of 22 for his friend. Adrian was secretary of the Club, with Chris Brasher (later Olympic Gold Medal for marathon) as President, and he selected George Band (later on the 1st successful Everest expedition) to follow him as secretary in the following year.

In the summer of 1949 Adrian and John Peirson (or Peterhouse) organized an expedition to Gomera in the Canary Islands, a choice influenced by two factors, having learnt Spanish at school, and having been impressed at an ornithology conference in Oxford by a report from David Lack and Southern about their study of bird distribution on Tenerife. With Paul Lloyd (later Vicar of ) and Phil Smith (a Vet), John and Adrian spent 2 months studying bird habitats at various altitudes including the unique arboreal heather forest in Gomera. Incidentally they illegally took David Bannerman's gun disguised as a walking stick all the way through Spain without it being noticed, and a few skins of shot birds from that expedition should be in the BM. Dr Cott (the animal coloration expert) of the Cambridge Zoology Museum had collected lizards on the Conaries about 1925, and warned them to look out for an unique indigenous pigeon, so they told everyone they wanted to see it. One day a poor woodsman came into their mountain camp among the tree heather carrying what could have been the last specimen on the island - dead. So they skinned it and ate the meat. "Los Quartros Ingleses" as they were called, walked over the whole island, watched the mariolatry festivals, lived on gofio, which is maize first toasted then ground in a watermill, explored all the ecological habitats, were thoroughly bitten by insect parasites, and published a paper on the ornithological results.

Adrian's first scientific paper, however, resulted from an accidental discovery of the alga *Falkenbergia* while he was camping on the Scilly Isles. He was working at the MBL Plymouth in 1950 after graduating and had taken the steamer from Penzance to camp on St Mary's. I think he was with Martin Canny (later Professor of Botany at Monash) and they stayed in a b & b on Tresco where Canny (an Australian) was looking at the distribution of plants. Anyway just before returning to Plymouth, Adrian collected some porcellanid crabs and snapping shrimps, intending to stain the nerves with methylene blue. Back at Plymouth the seaweed that the crabs were packed in turn out to be an Australian species of red alga almost new to Britain.

About this time, while doing Part II Zoology, Adrian came under the influence of Sydney Smith, an invertebrate entertainer and eater, steward of St Catherine College, and fond of discussion, musical evenings, wine and undergraduate parties on the river. The result was a period working in Sydney's lab putting tissue transplants into ectoderm explants from newt (*T. cristatus*) embryos of different ages - all good experience with sterile techniques and glass needles. That led to a thorough coverage of the literature on experimental embryology and regeneration. Another strong influence came from Dr Whiting, who taught the embryology of the nervous system and behaviour in lower vertebrates, notably the work of Coghill, Harrison and Hamburger, and who was really enthusiastic about specific neuron staining with silver and methylene blue.

After graduating Part II Zoology, Adrian knew exactly what he wanted to research on - unlike some of the new Ph.D students, and he went down to Plymouth to stay at Miss Geake's establishment. Grahame Hoyle was there, working on tunicate responses. Adrian shared a room with John Morton (later Professor of Zoology at Auckland) and learnt the methylene blue technique from Dr Alexandrowicz. He planned to study the regeneration of the neural connections in polychaetes, by following regeneration in certain worms that were known to stain well. His supervisor, Pantin had gone to Brazil and it was a year of frustration. He tried a variety of worms but the growing axons would not stain. He tried embryonic worm neurons but again no success. Back in Cambridge he tried leeches, earthworms, by silver staining and Cajal methods with poor results.

After the war the Zoology Department in Cambridge refined its concentration on the experimental method. The lab was plentiful in electronic

junk from the war. Boxes of it were purchased in bulk from Lyle Street in Soho. Soon Adrian bought a copy of Puckle's "Time Bases" and built his own stimulator, amplifiers and oscilloscope circuit. He modified a camera for use as an oscilloscope camera and started recording from earthworms with intention of following the course of regeneration of the giant fibres electrically. Nothing interesting came of it but the electronics later became his bread and butter technique. The Cambridge Zoology lab was also full of brilliant people at that time. Adrian shared a lab with Brian, one of the 3 Shaffer brothers (Peter the playwright is another) who produced Granta (once bottled by Tolly's). There were half-a-dozen Fellows of the Royal Society available to talk over tea, with another bunch of talent over the road in the Physiographical lab, where Hodgkin's technician taught Adrian to make microelectrodes by hand alone, with a quick pull. Rushton personally persuaded him to learn the modern technique of intracellular recording in that 1st year as a research student, stressing that this was the time for it. So it was a busy year although nothing much came of it all. Easter was spent at Naples, the first of many visits to the Stazione Zoologica, working on *Dinophilus*, *Protodrilus* and looking at everything available there. Harold Monro Fox was there with Eric Smith and they took a party on one memorable occasion to the local Neapolitan music hall. Lawrence Picken was there too, and they dined at Pozzuoli, discussing the ancient Greek settlements over dinner. Adrian went to Ischia and Casa Axel Munther on Capri, besides Paestum, Sorrento and Amalfi, again not for the first time. Eventually he learned Italian and stayed in Florence on every visit to Naples, wandering through the Uffizi, San Marco and Pizzi before the tourists had realized that the place had survived the war, and following the instructions in an old 1870 Baedeker guide. He picked up old copies of Dante and learnt chunks of the *Vita Nuova* by heart in trains, on one occasion making a list of Dante's marine metaphors. By this time he read five European languages, and spent at least half his time at Naples searching through the old literature in the library of the Stazione Zoologica. On his return from Brazil, Carl Pantin found that he had a new research student of independent tastes and considerable momentum, armed with a motor bike and electronic amplifying equipment (which Pantin never had). Very sensibly Pantin suggested Adrian have a look at coelenterates and at some old work published by G J Romanes in 1876. So a visit to Brancaster Staithe on the Norfolk coast was organized and Martin

Canny came along as well to study Oscillatoria (a microalga which wriggles). They set up a temporary lab in the boatshed of the Chestney family and came back to Cambridge with four breffits of the common white jellyfish Aurelia aurita, this is when the first discovery was made, that the living nerve net of Aurelia is visible under a low-power microscope with suitable illumination. There followed another year of perfecting techniques and another visit to Naples to work on stimulation of medusae of many kinds. Then in the summer of 1952 Adrian took his equipment to Millport on the Clyde where jellyfish would be common all later spring and summer. For lack of funds he camped, washed and cooked in the lab and generally poked his nose into everything that was going on. There was Barnes, Miller, Marshall and Orr, and the old director; Victor Rothschild was working there on sea urchin sperm and even James Gray spent some time there that summer.

At that time, all these trips were privately funded. A research student had to take himself off to Plymouth, Naples or Millport, and live as best he could on his grant of about Pound 350 per year. A student could live cheaply at a marine lab. He could boil one of the lobsters or get a fish from time to time, live and work in the lab, bath in the lab sink after hours, sometimes even sleep inside. It is a great pity that this kind of thing has become more regulated. That summer it proved possible to make bridges of jellyfish tissue so narrow that only one nerve fibre ran across them, and to record nerve impulses in the nerve net which controlled the movement of the bell. This was stuff worth publishing and the significance for the future was enormous. It was the first time that spikes had been recorded in a coelenterate nerve net. It led to the description of the two nerve nets of scyphozoan jellyfish (guessed by Bozler years before) and it later brought together Ted Bullock and Adrian Horridge, because Bullock had worked on jellyfish as well as on annelid giant fibres. Adrian wrote it up during late 1952 and presented a thesis for a prize fellowship at St John's College. He was elected along with Abdus Salaam in 1953. More work at Plymouth, Naples and Millport followed in the following year; this time he was assisted by a very attractive young lady.

Audrey Lightburne was one of 4 sisters all of whom went to Girton. She was a warm-hearted red-headed third year student of English, daughter of Rev. Harcourt Lightburne, Vicar of Upchurch, Kent (obit 1951). Audrey trained in Classics at Cheltenham College, was one of an active group of Girton girls, among them, Alice Kendon, Elizabeth Trowell (raised in Uganda) and Marianne

Friedenthal (European Jewish refugee). Exactly as in the mens' colleges, the mix was fascinating. Adrian had in fact been looking for a wife for some months, having adopted a practical scientific method. He had purchased two season tickets for the Arts Theatre, expressly as an incentive to himself to get on with it every week, and as a bait to any girl who took his fancy each week. He had got through a few weeks already without a durable result; in fact one hussy had refused to come a second time. With Audrey, the show that week was rather sexy, and she obviously enjoyed it - a good sign.

In those years, a man was obliged to go into the Armed Forces before the age of 26 unless he could find a reserved occupation. Mark Pryor at Cambridge had worked on the radar - transparent Balsa aeroplane - the <sup>Mosquito</sup> during the war in a group at Farnborough Royal Aircraft Establishment. Mark now recommended that Adrian take a job in that group under Jim Gordon (later Professor of Engineering, Reading, and author of "Why we don't fall through the floor"). So he duly turned up for duty there in 1953 and moved into digs in Aldershot. What an unfamiliar world. Unlike the rest of the Scientific Civil Service, the group seemed to have some sparkle. Adrian's job was to learn everything about making rockets, aeroplanes, and radar reflectors from fibre-reinforced plastics, and then utilize his knowledge of biological structures to improve the fibre orientations and assembly of the reinforced plastic. The idea was to make synthetic lobster-claws into aeroplane fins, egg-shaped domes, or aeroplane structures with the fibre pattern of tree branches. Even the fibre-orientation in worm's cuticle was copied into the casings of rockets. It involved the laws of scale, the properties of rivets versus glue joints, problems of delamination of plastic wafers, moulding techniques, pressures in solid-fuel rockets, loadings on wings or wind loading on radomes. Jim Gordon had a belief that D'Arcy Thomson in his "Growth and Form" was the prophet of the future engineers of new materials. He discussed growing plastic structures by pulling the fibres into line along the stresses and across the cracks (as in bone) and of making new fibres by crystal overgrowth. The results were spectacular but all secret at the time. Cory Phillips in Gordon's group was involved in the invention of the carbon fibre. Fiber-reinforced plastic turbine blades were first made by John Horlock (later FRS, Vice Chancelry, the Open University), a friend of Adrian's in St John's College at the time. The idea of spiral winding thermosetting plastic with glass fibre <sup>W</sup>as tested successfully in numerous firings of solid

fuel rockets. Adrian's best success was to invent the material for the heat-resistant strong pipe which conducted the fast stream of hot gases from the centre of the solid cordite charge to the rocket venturi. His worst was the preservation of Cody's Tree by embedding it in polyester resin - a mistake because it became so heavy it would not support its own weight. Cody's tree was the pine tree to which Col. Cody moored his aeoplane by a spring balance when he tested the thrust of experimental propellers about 1950. The tree died standing and was rotting away by 1953.

Every weekend was spent either in Cambridge or at the Lightburne home, which was then the sturdy stone vicarage in the centre of the beautiful village of Wytham just outside Oxford, on the road beyond the Trout Inn. Travel was first by motor bike and later partly in an old Ford Anglia that had been acquired for nothing. One day when hen Jim Gordon was the passenger, a spring broke near Gerrard's Cross and they had to roll up the rubber floor mat and insert it while the car was jacked up. After that the car would go around only in a left-hand direction. Later, the same car lost its floor to corrosion so it was useless on wet days, and eventually its cooling system became so useless that it had to run without water and was good for only a few miles. So much for being the son of a motor dealer and mechanic.

Wytham Rectory became a second home for 1953 and 1954. Adrian and Audrey were married in <sup>W</sup>cytham church by Henry Hill (now Bishop of Kingston Ontario) and they lived for a few months in a dreadful little flatlet in Farnborough in a house that stank of cats. When they left Adrian nailed a kipper on the underside of the table and abandoned another on the top of wardrobe. In Sept 1954 they moved to a flat (previously occupied by John Trehe<sup>n</sup>ue) on the top floor of the vicarage at Stow-cum-Quy from where they went brass-rubbing and duckshooting on the fens. Audrey taught English to foreigners at the Davis School in Station Road, while Adrian spent two glorious years as a Fellow of St Johns with no duties. Not much experimental work on ceolenterates could be done in Cambridge. They kept bees in Quy; both went to Naples at Easter and Adrian spent the summer at Guardaqa on the Red Sea coast of Egypt. He went with a grant of £100 from the Royal Society to study a giant polychaete of which a specimen collected by Hickson is in the Cambridge Museum - but never saw one, so instead he turned to corals, working on their excitability as if they were merely colonies of sea anemones connected by a nerve net. The paper introduced the idea that the colonial nerve net has statistical properties

depending on the proportion of open synapses, with the provision for further spread of excitation by opening of synapses with each successive impulse. This two-dimensional Queue theory problem was solved by an analogue model, which was a board of wood with 10,000 holes representing synapses in an endless roll-around-the-edges nerve net. Again Bullock in Los Angeles noticed this and put at least a couple of his students on the job of checking it with corals at <sup>Eniwetok</sup> ~~Eniwetok~~ in the Caroline Is. One of them was Bob Josephson, later on the  $\alpha$  Helix at Banda.

While they were all at Naples in 1955, with Audrey, Carl Pantin announced that a job was available at St Andrews and that Adrian really should apply because there was a marine laboratory there. So a hurried application was sent off and it <sup>was</sup> ~~was~~ so brief that the Professor of Zoology at St Andrews, Mick Callan, put it in the wastepaper basket at first; then fished it out for a second look because it came from Naples. At the interview in St Andrews Adrian asked about housing and was told that land and houses were in short supply. Adrian's suggestion that the dune lands (The Royal and Ancient Golf Course) by the railway station looked like prime building land was not greeted with enthusiasm. Instead it was suggested that the town needed a few English martyrs to mark the paving stones.

They settled in the village of Boarhills on the road to Crail, four miles from St Andrews, where they lived for 9 years, with 1959 spent in the USA. There was everything to be done. The garden was productive but had to be dug; village life was hearty and hilarious at times, being almost feudal with the farm labourers living in tied cottages that belonged to the three farms. There was plenty of shooting for hares, ducks, pigeons and a few pheasants, good honest neighbours, village whist drives and dances. At the lab there were new lecture courses to be written, entirely new experimental practical classes to be designed and equipped. For this job, a farm labourer, Herbert, was employed as a technician, taught to make stimulators and amplifiers and within a year he had built enough equipment for a class of 30 to stimulate and record from nerves, all done with second-hand components bought in Soho.

By 1957 Bullock had sent to Adrian the chapter on Coelenterates of a book which was planned to cover the nervous systems of all the invertebrates. Bullock wanted comments but Adrian tore the chapter to pieces and rewrote parts of it. Thereupon Bullock sent an invitation to him to join him as co-author and spend some time in California. Professor Callan did not like the

idea at all, and insisted that Adrian give the lectures on comparative physiology in October 1958. So the family, by this time with 2 children, Mark and Alison, left for California for 15 months in June 1958 but Adrian had to fly back and give his lectures in the autumn.

Adrian had opted to do the arthropod chapters in the new book, while Bullock did the molluscs. Again, this decision lightly taken at the time, had a decisive effect on subsequent research. Before 1959 Adrian had worked on coelenterates, annelids and molluscs. After 1960, apart from moderizing the neurobiology of the ctenophores, which were a neglected group, he never looked outside crustacean and insect vision. Writing a comprehensive book of that scope generates endless insights into the literature, and the subsequent 10 years to 1969 at the Gatty saw the fruition of that preparation and thought. California and book writing was a marvellous experience, skiing at Badger Pass, visits to Monterey, motoring up the west coast to Friday Harbor in the San Juan Islands on the Canadian border, a visit to the desert, Marineland, and giant redwoods. New friends there were too, at Stanford, Berkeley and new neighbours in Menlo Park, for example Gus Nossal was living in Menlo Park that year.

The sixties at the Gatty Marine lab was one of those golden periods where all things conspire towards the good. Three research students arrived, David Sandeman (now Professor at University of NSW), John Scholes (now at MRC Drury Lane) and Reg Chapman (now Professor of Physiology at Bristol) soon to be followed by five others including Malc Burrows (now FRS, personal Professor in Cambridge University) and John Armson (now Principal of Edinburgh Anglican Theological College). Also Sid Tamm turned up to work on cilia and found his future wife in St Andrews. Sid came to work on ctenophores but Adrian remembered a conversation of years before with Lawrence Picken who had described how a Hungarian had described the rotating stroke of the cilia of Opalina, a parasite in frog bladder. So they fixed some Opalina in hot osmic acid and went by train to Edinburgh to use a new instrument, the scanning electron microscope, returning with pictures that have been repeatedly republished. That was the beginning of Tamm's story of the endlessly rotating flagella in termite parasites. Also the ctenophore Beroë had yielded a macrocilium which gave away the clue that cilia actively beat by sliding of adjacent pairs of microtubules, before Peter Satir proved the same in normal cilia. Sid Tamm was still publishing on macrocilia of Beroë in 1986. The

cilia stories, including vibration sensitive sensory cilia of coelenterates, were fundamental, the ctenophores were pure fun, but the neural basis of their behaviour was revised for the whole group. The main work at the Gatty was on the crab eye with Sandeman on the optomotor response, with Burrows on the control of the eyecup muscles and Adrian on the modification of the eyestalk reflexes. Twelve papers on crab eye were published in 2 lots of 6, one lot being Adrian's own work on optokinetic memory - the ability of a crab to respond when it has to remember over a dark period the former position of the stimulating pattern. In 1966 he published 26 papers. Meanwhile at home there were 4 children in a new house that Adrian had designed for Scotland, with an outer wall of foamed cement, impermeable to cold.

One of the students at the Gatty, John Scholes, after fooling around with in learning earthworms, started to work on locust eye, about which a stupid theory had just been published in PRS(B) in 1962. Adrian had seen microelectrode pullers in California and had them made in the Gatty workshop, which was newly built, staffed and equipped. He also designed a system for stimulating eyes from any angle, based on a second hand theodelite, again purchased in Soho, with a lamp in the place of the telescope. By chance Scholes noticed miniature potentials while recording intracellularly from locust primary visual cells. They were potentials caused by single photon captures. That was the start of the long effort on the compound eye, which later became the main topic at Canberra.

The locusts had been sent for class experiments, and Adrian had also in 1961 demonstrated the pitch discrimination of the locust ear by recording from the second-order cells, in the ventral cord. A new technician was appointed, a former postman who had been out of work for years and he was trained to rear locusts so well that it was said that he grew to look like one.

The sixties were golden years at the Gatty. The first attraction was the self-galvanizing little community of scientists interested in working out animal mechanisms using a variety of strange invertebrates, in an attractive old building with running seawater, tanks of anemones, crabs, lobsters and octopus. It was not so much the quality of the science, it was the enthusiasm of the occupants that led to the varied output. Intense work was sometimes essential; really new ideas turned up from time to time; day to day contact was fun; the occupants enjoyed each others company for the most part and work was continual. The second secret was the appeal of a wide range of strange

behaviour patterns controlled by relatively simple nervous systems which almost offered themselves to be discovered.

In 1967 the Department of Biology at Yale found themselves in difficulty with no-one to give the course in comparative nervous systems, and urgently invited Adrian as a member of their Faculty for six months for a lump sum of \$10,000. Because of responsibilities at home and at the Gatty, he commuted between Newhaven and Scotland every few weeks, to the astonishment of the frugal locals at St Andrews, and while at Yale he wrote the draft of a book "Interneurons" that was largely the content of the Course. That book was an expression of many topics not included in the large tome with Bullock, and many disturbing new ideas about the fundamental difficulties of solving the basic problem of how the brain works. The theme reappears in the article in BIOSCIENCE FOR NO. 1977 "Mechanistic Teleology and Explanation in Neuroethology". The book also revealed the uncertain state of knowledge on the mechanisms of various compound eyes, later to be followed up in details. In 1968 an invitation brought the whole family to Wood's Hole Marine Biological Laboratory on an Ely Lilley Fellowship, along with Steve Shaw and his wife. There was a mysterious visit from Professor Dennis Carr from Canberra, and a telegram asking Adrian to visit Canberra, so he flew to Australia from Wood's Hole to see what ANU had to offer. It was not unexpected, because Professor David Catcheside, FRS, formerly at Cambridge, and in 1968 the Director of the newly founded Research School of Biological Sciences, had made a visit to St Andrews to inspect the Gatty and meet everyone there with the possibility of an offer. The visit to Canberra was made the occasion of a formal interview, which led to an offer of the foundation chair of Behavioural Biology. Adrian took the opportunity to visit Hobart, Melbourne (where he stayed with Geoff Burnstock) and he looked over the Walter and Eliza Hall Institute, then visited Cronulla, Brisbane, Townsville, Lae in PNG, Honiara in the Solomon Is, and the University of Suva in Fiji. That journey, backed by the promises from Canberra, laid the foundations for a new life, not only for him and his family, but for dozens who would join him in Canberra in the ensuing years. The keynote of all that was new opportunity - the Vita Nuova. In Townsville, Professor Burdon-Jones discussed a proposal for a new marine laboratory, which in 1968 was being prepared for submission. That proposal was picked out for political reasons (there was a bye-election), and it became the Australian Institute of Marine

Science, but later everyone thought it stupid to place it so far from the town. Back home in Scotland, the Council of the Marine Biological Laboratory at Millport, of which Adrian was a member for 10 years had just succeeded in moving their lab from the island of Millport to the mainland near Oban to overcome isolation. In the event, even Oban was to prove rather isolated.

Back at Wood's Hole the family were told about the offer. Audrey was taken with the idea of Australia but insisted that it be in writing. Back at St Andrews no-one knew of the turn of events, but there was talk of creating a Professorship for the Director of the Gatty Marine Laboratory. In the event St Andrews were too slow and the effort moved to Australia. David Sandeman was enlisted on the staff of the new department at Canberra, Ian Meinertzhagen was sent out to Canberra at Easter 1969 and Bob Jackson was appointed there as Technical Officer for the new department. Altogether 19 people including wives and children left England for new lives in Australia, three of them Butler, Ioannides and Shelton, in the midst of their Ph.D. A post-doctoral Ben Walcott now (Professor of Stonybrook, NY, USA) came and married an Australian girl to take back to America. David Young came from Cardiff and Eldon Ball from Stanford. There was a surprisingly rapid transition because they came as a substantial trained group; everyone knew how to set up quickly. There were funds for all the equipment really needed, there was a pioneer spirit, a feeling of mission to the southern hemisphere.

On the home front, life had no frustrations, the three girls went to school in Canberra. Mark won a scholarship to Geelong Grammar, took himself off there, spent his holidays bushwalking, and virtually left the family circle. He was later at ANU at the age of 16, was a student activist in the Whitlam era, and finally went to Cambridge as an undergraduate again. There he was unhappy, but after graduation he set up a successful printing cooperative The Fly Press in Brixton, London, where he worked for 2 years before returning to Australia. Alison graduated from ANU in Chinese and Geography; Naomi eventually transferred to Melbourne to finish a degree in Fine Arts; Rebecca became a medical student in Melbourne then transferred to Arts. By 1985, 3 children (not Alison) were living in central Melbourne and Mark had bought a house there. The family house in National Circuit, with its beautiful garden, rooms to sleep 7 and huge homely sitting room, was no longer fully used. It had seen swings and guinea pigs, fruit trees planted, boats and bicycles, kilograms of peaches, berries, persimmons and nectarines,

parties for social workers, parties for neurobiologists, endless writing done there, but it was not a home for adult children because they had no privacy except in small rooms. So in 1986 it was decided to move to 76 Mueller Street, Yarralumla, by Weston Park, by Lake Burley Griffin.

Let me go back now to the early 70's. The topic for research was the compound eye for Adrian and his students, a variety of insect neurobiology topic including insect hearing for Ball and Young, insect flight for Tyrer, Altman and for Malcomb Burrows when he visited. In 1973 a new building was completed for the whole of RSBS, and new topics were initiated. Meinertzhagen working on compound eye development was joined by Mike Bate and Paul Whittington on insect CNS development. The post-doctoral fellows were selected on promise and brilliance, not so much by topic. In fact, those selected for their topic were usually relative failures. A new biochemistry lab was started by Jeff Denburg, working on specific proteins of insect neurons and muscles. Those were early days for gel electrophoresis of single cells, and Geff showed that individual muscles of insects have specifically different membrane proteins.

At the time Adrian was mainly rearing his family and looking at eye structure in as many arthropods as he could get hold of, beetles, moths, mayflies, flies, dragonflies, in fact everything that came to hand, or which could be caught on local expeditions. It was a way to combine collecting with exploration of a new country. One of his regrets was that none of his children picked up his enthusiasm for natural history.

In 1972 Allan Snyder arrived from Yale to join the department of Applied Maths in RSPHYS. Allan was keen on vision even in those days, although he had not then done his best work in fibre optics. One of his reasons for coming to Canberra was the existence of two vision groups there, Bishop and Levick in the JCSMR and Horridge in RSBS. Soon the work on the insect eye became more mathematical, first with reference to the light-guide action of the rhabdoms, then (after 1976) in the study of the eye as an array of sampling stations. Although much of this early work later had to be corrected in detail, the whole subject of the compound eye was revolutionized by the Canberra group. The factors in this upgrading of the subject were optics, electronmicroscopy and electrophysiology. Adrian insisted that every student and his own post-docs, should record intracellularly. The appropriate stimulating equipment was passed down from generation to generation of students. The rule was to do

an experiment every day. Group after group of insects (and some spiders) were tackled; the structure was slowly worked out, pigment movements were followed and the function of the retina analysed in group after group. Rando~~ff~~ Menzel (now Professor in Berlin) learnt intracellular recording on bee eyes in Canberra where he managed to record from the 9th cell and also from lamina ganglion cells. Laughlin began on retinula cells of the bee and dragonfly then moved to the lamina.

By 1973 the department could run itself and Adrian spent the year in Oxford working with Malcomb Burrows, his ex-student, and relaxed as a Fellow of Balliol. The children went to school in Oxford and the family rented John Pringle's house. It was that~~s~~ year in Oxford which showed that Australia had more to offer to all the family than England. There would be no sudden return.

In 1975 another event changed the course of work, lives, and eventually of Adrian's whole outlook, Professor Jim Case of U.C. Santa Barbara, invited Adrian to join him in leading an expedition to the Banda Sea, Indonesia with the US Research ship,  $\alpha$  Helix. This famous ship had taken groups of scientists, with their equipment, to many odd corners of the world. Eldon Ball and Jim Case had been on the north coast of Papua in the  $\alpha$  Helix the previous year. Adrian extracted \$20,000 from the Department of Science to help towards costs. In 1976 the  $\alpha$  Helix picked up equipment, with Ball and <sup>?</sup> in Cairns. Adrian, Martin Wilson, Peter Simmons, and found their way to Ambon in the Moluccas to join the ship and set up a base camp in the house of Des Alewi on Banda Neira. There they worked for 2 months, explored, scuba dived on the beautiful unspoilt coral reefs, learnt Indonesian and there Adrian made eye maps and discovered the diversity of arthropod foveas. It was an approach that led Allan Sndyer into the analysis of eyes as sampling arrays, for which Allan needed a survey of interommatidial angles and of field sizes. It all finally emerged in 1978 - Adrian's paper in Phil Trans on the axes in apposition compound eyes, and the paper by Snyder, Laughlin and Stavenga on the information transmission in compound eyes in relation to photon noise. At that time, also, two students, Hardy and Lillywhite were recording from flies and locusts to provide data on fields and photon capture efficiency. It looked as if all the exciting work was done on the apposition eye retina and it was time to turn elsewhere.

On the  $\alpha$  Helix expedition, Adrian had walked one day into a boatyard in a village of atap-houses at the west end of Banda Neira. The boats were sturdy single or 2-masted sloops, which looked superficially like English herring boats of 1880 but were built of hand-carved hardwood planks held together by dowels hidden within the plank-edges. Here was a new subject for investigation. Where did the tradition come from? What were the design principles on which these boats were built? What is the story of eastern boatbuilding? Every detail was photographed; the name for every part was written down; the lives of the builders, the owners, the sailors, were written into notes. On his return to Australia, Adrian tried to find some literature on the subject but almost a blank ensued. He wrote to the main museums in Holland and arranged to call there in the following year. He photographed most of the models in the Dutch museums - now neglected along with other Dutch interest in Indonesia. In 1977, on the way to visit Cambridge as a Fellow of Churchill College, he stopped off in Indonesia, found Philippe Pétiniand building a boat in Bali, then went to the boatbuilding homeland of the Bugis in South Sulawesi. At Tana Beru, Ara, Makassar and Bulukumba he found a different boatbuilding tradition, recorded it, talked long with the master boatbuilders and decided to write on the subject. Much of the writing of the first three monographs published by the Maritime Museum at Greenwich (Nos. 38, 39, and 40) was done in Cambridge as a fellow of Churchill during 1978.

In 1978 Adrian was invited by the Lembaga Oceanologi at Indonesia to participate in a survey by ship around the islands of Aru, Kei, Banda and Ambon, based on the Marine laboratory of the University of Pattimura at Ambon. Not much marine science was done, especially after the dredge was lost off the Aru Islands, but the great discovery was the lashed-lug construction of the prahu belang on Aru - virtually a Bronze Age boat.

Back home, totally by chance, Professor Scott, an American working on the traditional cultural<sup>2</sup> of Luzon, happened to be in Canberra to consult MSs material in the National Library. Some chance introduction brought him to consult Adrian on how to make sense of an old Spanish MS on native boatbuilding in the Philippines by Fr Alcina (1685). That led to Adrian's full translation which formed the basis of Monograph 54 of the N.M.M. Greenwich. Fortunately that was not published before a visit in 1980 to the whaling village of Lamalerap on Lomblem had revealed another living example of the lashed-lug boat. On this remote island of animistic cultures facing the

Straits of Timor, is the last surviving eastern tropical whaling village where sperm whales are speared by hand-made harpoons thrown from boats that are constructed by Neolithic techniques.

A visit to a different part of Indonesia each year from 1975 onwards provided material for the hurried writing of a book on "The Prah" (1981) which provided for the first time a comprehensive set of descriptions of the main types of Indonesian traditional boats, with notes on usage, on the cultures that build and sail them, design and construction, rigs and distribution. A main theme was the variety of boatbuilding technology and rigs, and the impact of Western designs on the traditional Eastern boatbuilding methods. Basically the book was a first guide to the topic, and was illustrated with 40 photographs and 70 drawings (most of them by Chris Snoek). A second edition appeared in 1986.

A small pocket book of prahu types was also published by Oxford in Asia in 1986. Meanwhile a monograph on "the Outrigger Canoes of Bali and Madura" was sent off in 1986 for publication with the Bishop Museum at Honolulu, with 72 line drawings by the author.

Two themes new to science were explored in this work on outrigger canoes. Analysis of the ceremonies at building, and at the Balinese New Year (Galungan) showed that the stem of the canoe is a male part, the hull is female, analogous to the female keel and its male extension in the plank built boats. The "marriage" of the two parts, in a ceremony full of sexual symbolism, quickens the spirit of the canoe or prahu and provides a home for the in-dwelling spirit which is honoured in regular ceremonies. Secondly, it was suggested that the Madurese Jukung Rig is ancestral to all rigs of the Pacific cultures and could have evolved on rafts before the invention of the outrigger canoe. This Madurese rig, not previously described in detail, has a two-boomed triangular sail pushed up by a loose supporting prop (not a mast) which is supported sideways by stays to the outrigger booms.

Besides the romance and colour of the topic, the fascination of this work on Indonesian boats and canoes to Adrian was the variety of skills demanded. Besides having to be a tough traveller, able to work in the humid tropics, able to get first class photographs in difficult conditions, to travel by local bus and prahu, it involved knowing the adat to gain an entry, speaking Balasa Indonesia, having lists of words of boat terminology in 20 island dialects, being able to see the principles of engineering design at a glance,

knowing about sailing boats, rigs, wind, waves, weather, fishing methods, timbers, ceremonies and the whole history of the Austronesian peoples that sent off the Polynesians into the Pacific. Back home, it meant reading the French, Dutch, German, Spanish and Malay, printing photographs, making endless drawings from them and writing a coherent account. At the same time there was the full-time job as Professor of Neurobiology.

In 1978 Adrian had decided that he would have his own set-up for recording from a variety of strange eyes, and he had appointed Ljerka Marcelya as research assistant. Then began a long collaborative effort that combined optics, anatomy and recordings from photoreceptors in many curious eyes. It was discovered that the mayfly dorsal eye (in Atelophlebia) is sensitive only to ultraviolet light, and that UV light crosses the clear zone by light guides. In the water beetle Macrogyrus, counting the photon captures in the photoreceptors gave a measure of the optical gain of the superposition eye. In the diurnal moths (Agaristidae), direct recording demonstrated that the superposition image is perfectly focused on the receptor layer. Also out of this work on a range of insects came the data which showed the profound effect of the diurnal rhythm on the pigment migration and change in size of the locust and mantid rhabdom, but no diurnal effect on the transduction process. One of the bye-products was the discovery of large tensile forces in the day eye and their relaxation in the night eye. In this work, facts were published only once, in the expectation that a book would eventually put it all into context.

In 1983/4 the department of Neurobiology was at a low ebb because funds had been kept in reserve for the appointment of a second Professor, who eventually never materialized. The idea of second chair had been approved as a convenient move in a manoeuvring for power that suited all sides while Professor John was Director of RSBS. The University administration were dilatory in getting out an offer, and hopeless when it came to attracting a candidate. Professor John had no idea whether he was trying to supplant the old Professor of Neurobiology, or whether he was being used to strengthen a department of which he disapproved. As it turned out, Professor John retired as Director of RSBS in Sept 1986, and then took early retirement in 1985. In the new regime under Ralph Slatyer, heads of departments became free to use their funds as best they could to promote their research. At the same time, Simon Laughlin accepted an appointment at Cambridge. Laughlin had become the

main strength of the department in the study of the early stages of visual processing but could not form a sufficiently large group which would be identified as his own. By 1982, after 10 years in Neurobiology, he made a strong effort to turn to the vertebrate retina, but it became obvious to all that it was time for a move. In fact, it was problems of organization which provided the initial impetus for the proposal for a second chair and for Laughlin's move.

Adrian responded immediately to the freeing of the funds by travelling privately to China in 1984 where he arranged a collaboration with the Institute of Biophysics of Academia Sinica in Beijing. China was newly open to individual travellers in 1984 and the best of their scientists were looking for opportunities overseas. Alison Horridge, fresh from 6 months in Taiwan, and armed with a Chinese student card, met her father in Beijing and together they toured Beijing, Xian, Sechuan, Chungking, and down the Yangste River to Wuhan. An insect eye anatomist, Dr Wu Wei-guo, was brought to Canberra for a year, and two Chinese Ph.D students were enrolled in Neurobiology. A Chinese secretary from Hong Kong, Lilian Chan, appeared in the department. In 1986 Adrian was back in China as a guest of the Academia Sinica and he now established many contacts, but it was perhaps too late because China was beginning to experience a serious brain drain and there were signs that new graduates would not be allowed passports to leave China so easily.

The response to Laughlin's departure was also swift. Dr Mandyam Srinivasan was appointed as tenured replacement, and four post-docs were appointed in the general area of visual processing. Two, Maddess and Guy with Srinivasan, and two, Reye and Findlay with Adrian, formed the backbone of a new group on visual processing by the insect optic lobe. The general aim was to find the principles of action of optic lobe neurons in vision, with the insect as example. The strategy was to use the general purpose electrophysiology equipment in the department, transferred from work on retina. The justification for this research topic is that we have no effective way to make simple artificial eyes that really process their own visual data, but such simple eyes would be extremely useful, for examples as aids for robot fingers, seeing devices for the blind, safety devices on the fronts of cars or on machinery, surveillance equipment, etc.

If we had learned any major scientific principles from the study of eyes, it was that to understand vision we have to understand in three directions the

formal principles of what eyes are designed to do. We must discover what the eyes are evolved to abstract from the whole visual world; we must discover what outputs they control and we must measure the features of the outside world with which the eye has to cope. It has never been clear that insects see as we do, by reconstruction of the scene, and certainly they have no visual cortex and their visual neurons are not dominated by the centre-surround and bar-detectors that are the main feature of the vertebrates early visual pathway. Like vertebrate they cope with a  $10^7$  range in intensity and the early processing stages detect contrast change and motion, but any eye must do that.

In late 1986, Adrian produced a new theory of insect vision, based on the discontinuities caused by nearby objects in the visual flow field that is induced by self-motion. More to the point, tests on object perception by mantids (which have binocular vision for capture of moving prey) suggested that they see objects mainly by parallax. In fact they appear to appreciate the independent existence of objects by their relative motion against the background. After all, insects can never learn about the shape and textures of objects by picking them up and feeling them, or by relating vision to touch, as babies do while they slowly educate their visual cortex. Insects have no cortex, but they readily see movement against background; they walk, fly, chose mates or prey and generally behave as if they see objects. Perhaps to copy insect optic lobes would be the easy way to make a specialized range of simple seeing devices for man.

Besides the uniqueness and idiosyncrasy of the topic, the attraction of research on insect vision for Adrian lay in the diversity of topics and techniques that were brought together into one framework of thought. First you go far to catch a nocturnal dragonfly, a mountain grasshopper or a mayfly, or you rear caterpillars at home. Then you examine the optics by scan EM and interference microscopy, then reconstruct the anatomy by day and by night (not the same) by electron microscopy, set up the electrophysiological recording, inject dye into single cells by microelectrode, recover the cell anatomically and identify it; then you make a computer model of how neurons interact, then look at the responses of the next neurons down the line to see what they receive, then at deeper neurons to try to make sense of their complex fields; finally you study the behaviour to try to determine what aspects of the visual world they see, and how the visual behaviour may be related to the neuron reponses within the optic lobes.

Like the work on Indonesian boats, the study of compound eye has been integrative, always aimed at completing the picture by finding holes in it and patching them quickly, never aimed at finer and finer detail on a limited topic. With some scientists the integrative approach leads to disapproval, mainly because scientists are self-selected to work on a narrow field in a sheltered workshop. The main problem in following the integrative approach is that a 10 year period of dedication is essential because numerous personal skills are needed, together with numerous collaborating specialists who can pick on errors in their own areas that escape the generalist. A secondary problem is the shortage of hours in the day and the necessity to work at the limit of technical feasibility. The great advantage of being a serious generalist is that life is never again dull and the natural world returns a broad-based attention by revealing large areas of its hidden mysteries which are not so readily seen by narrow specialists.

## **GEORGE ADRIAN HORRIDGE: Brief CV**

Born 12 December 1927 Sheffield, UK

1946: Completed high school

1948: Bachelor of Arts (Cambridge).

1949: Master of Arts (Cambridge).

1952: PhD, St. Johns College (Cambridge).

1953-54: Assistant at the Royal Aircraft Establishment in Farnborough, UK.

1956: Doctor of Science (ScD) (Cambridge).

1956-68: Director of the Gatty Marine Laboratory at St. Andrew's University, UK.

1956-68: Lecturer then Reader in Zoology at St. Andrew's University, UK.

1959-60: Fellow of the Centre for Advanced Study in the Behavioral Sciences at Stanford University, USA.

1968- 1992: Professor and Head of Neurobiology at the Australian National University, Canberra, Australia.

1972-73: Visiting Fellow of Balliol College at Oxford University, UK.

1976-77: Visiting Fellow of Churchill College at the University of Cambridge, UK.

Retired officially in 1992

### ***Honours:***

1968: Zoological Society of London Scientific Medal for work on the anatomy and physiology of nervous systems of invertebrates.

1969: Elected to the Fellowship of the Royal Society (FRS)

1971: Elected to the Fellowship of the Australian Academy of Science (FAA)

2001: Australian Centenary Medal: 2001 for service to Australian Society in the Biological Sciences.

## **G.A. Horridge: List of Publications**

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Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

7005370135

The relevance of honeybee vision to the design of seeing systems

(2002) Proceedings of the 7th International Conference on Control, Automation, Robotics and Vision, ICARCV 2002, pp. 1122 - 1125

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[2342436804&partnerID=40&md5=eaf28f268cb6851101cb414acf26ab45](https://www.scopus.com/inward/record.uri?eid=2-s2.0-2342436804&partnerID=40&md5=eaf28f268cb6851101cb414acf26ab45)

AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian National University, Canberra, ACT 2601, Australia

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Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

7005370135

What the honeybee sees: A review of the recognition system of *Apis mellifera*

(2005) Physiological Entomology, 30 (1), pp. 2 - 13

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Horridge G.A., Giddings C., Wilson M.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Giddings, C. (58335130700); Wilson, M. (55547112901)

7005370135; 58335130700; 55547112901

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AFFILIATIONS: Australian National University, Canberra City ACT 2601, P.O. Box 475, Australia  
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Tsukahara Y., Horridge G.A., Stavenga D.G.  
AUTHOR FULL NAMES: Tsukahara, Y. (7103255448); Horridge, G.A. (7005370135); Stavenga, D.G. (7003316647)  
7103255448; 7005370135; 7003316647  
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AUTHOR FULL NAMES: Tsukahara, Y. (7103255448); Horridge, G.A. (7005370135)

7103255448; 7005370135

Interaction between two retinula cell types in the anterior eye of the dronefly *Eristalis*

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AFFILIATIONS: Department of Neurobiology, Research School of Biological Sciences, Australian National University, Canberra, 2600, A.C.T., Australia

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Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian National University, Canberra, ACT 2601, P.O. Box 475, Australia

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AFFILIATIONS: Australia

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Srinivasan M.V., Lehrer M., Zhang S.W., Horridge G.A.

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PUBLISHER: Springer-Verlag  
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Horridge G.A., Zhang S.W., Lehrer M.  
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Srinivasan M.V., Lehrer M., Horridge G.A.  
AUTHOR FULL NAMES: Srinivasan, M.V. (7203044676); Lehrer, M. (7006462837);  
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AFFILIATIONS: Australia  
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ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.  
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Diesendorf M.O., Horridge G.A.  
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Horridge G.A., Meinertzhagen I.A.  
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DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A., Walcott B., Ioannides A.C.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Walcott, B. (7007043571);  
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ABBREVIATED SOURCE TITLE: Proc R Soc Lond B Biol Sci

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SOURCE: Scopus

Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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Visual Discrimination by the Honeybee (*Apis mellifera*)

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AFFILIATIONS: Australian National University, Research School of Biological Sciences, Canberra, Australia

PUBLISHER: Oxford University Press

ABBREVIATED SOURCE TITLE: How Anim. See the World: Comp. Behav., Biol., and Evol. of Vis.

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SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Burrows M.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Burrows, M. (7103139615)  
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ABBREVIATED SOURCE TITLE: Philos. Trans. R. Soc. Lond., B, Biol. Sci.  
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SOURCE: Scopus

Burrows M., Horridge G.A.  
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ABBREVIATED SOURCE TITLE: Philos. Trans. R. Soc. Lond., B, Biol. Sci.  
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Sobey P.J., Horridge G.A.  
AUTHOR FULL NAMES: Sobey, P.J. (6602384300); Horridge, G.A. (7005370135)  
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AFFILIATIONS: Australia  
PUBLISHER: Royal Society  
ABBREVIATED SOURCE TITLE: Proc. R. Soc. B Biol. Sci.  
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Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: J. Comp. Physiol. A Neuroethol. Sens. Neural. Behav. Physiol.  
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Horridge G.A., Osorio D., Jahnke R., Wu Wei-Guo  
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Denburg J.L., Seecof R.L., Horridge G.A.  
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AFFILIATIONS: Australia  
ABBREVIATED SOURCE TITLE: Brain Res.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
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Horridge A.  
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Horridge A.

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Zhang S.W., Srinivasan M.V., Horridge G.A.  
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Horridge G.A., McLean M., Stange G., Lillywhite P.G.  
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AFFILIATIONS: Australia  
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DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge A.  
AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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How bees distinguish colors

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[84928982613&doi=10.2147%2fEB.S77973&partnerID=40&md5=b9441bc52e29e66d50375d1f2b207c8f](https://www.scopus.com/inward/record.uri?eid=2-s2.0-84928982613&doi=10.2147%2fEB.S77973&partnerID=40&md5=b9441bc52e29e66d50375d1f2b207c8f)

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Lehrer M., Horridge G.A., Zhang S.W., Gadagkar R.

AUTHOR FULL NAMES: Lehrer, M. (7006462837); Horridge, G.A. (7005370135); Zhang, S.W. (59063364000); Gadagkar, R. (7005626554)

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AFFILIATIONS: Switzerland

PUBLISHER: Royal Society

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DOCUMENT TYPE: Article

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OPEN ACCESS: All Open Access; Green Open Access

SOURCE: Scopus

Horridge G.A., Mclean M.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Mclean, M. (59076846800)

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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Barnes W.J., Horridge G.A.  
AUTHOR FULL NAMES: Barnes, W.J. (59877499500); Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: J Exp Biol  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, A. (7005370135)  
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ABBREVIATED SOURCE TITLE: J. Insect Physiol.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge A.

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AFFILIATIONS: Australian National University, Australia

PUBLISHER: Dadant and Sons, Inc

ABBREVIATED SOURCE TITLE: Am. Bee J.

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PUBLICATION STAGE: Final

SOURCE: Scopus

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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Mimura K., Tsukahara Y.

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: Behav. Brain Sci.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Tsukahara Y.

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ABBREVIATED SOURCE TITLE: J Exp Biol

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Snyder A.W., Horridge G.A.

AUTHOR FULL NAMES: Snyder, Allan W. (7202060582); Horridge, G.A. (7005370135)  
7202060582; 7005370135

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ABBREVIATED SOURCE TITLE: J. Comp. Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Laughlin S.B., Horridge G.A.

AUTHOR FULL NAMES: Laughlin, S.B. (7006757320); Horridge, G.A. (7005370135)

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ABBREVIATED SOURCE TITLE: Z. Vergl. Physiol.

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Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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ABBREVIATED SOURCE TITLE: Philos. Trans. R. Soc. Lond., B, Biol. Sci.

DOCUMENT TYPE: Article

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Centre for Visual Sciences, Research School of Biological Sciences,  
Australian National University, Canberra, Australia

ABBREVIATED SOURCE TITLE: *Acta. Biol. Hung.*

DOCUMENT TYPE: Review

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Marcelja L.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Marcelja, L. (6507668235)  
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AFFILIATIONS: Centre for Visual Sciences, Research School Biological Sciences,  
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PUBLISHER: Royal Society

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SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G. Adrian (7005370135)  
7005370135

Discrimination of single bars by the honeybee (*Apis mellifera*)

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SOURCE: Scopus

Horridge G.A., Giddings C.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Giddings, C. (6701585135)  
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The ommatidium of the termite *Mastotermes darwiniensis*  
(1971) *Tissue and Cell*, 3 (3), pp. 463 - 476  
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DOCUMENT TYPE: Article  
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SOURCE: Scopus

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Vision of the honeybee *Apis mellifera* for patterns with one pair of equal orthogonal bars  
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AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian  
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ABBREVIATED SOURCE TITLE: *J. INSECT PHYSIOL.*  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
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Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G. Adrian (7005370135)  
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DOCUMENT TYPE: Article  
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SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: Behav. Brain Sci.  
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(2005) Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology, 191 (4), pp. 301 - 316  
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DOCUMENT TYPE: Review  
PUBLICATION STAGE: Final  
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ABBREVIATED SOURCE TITLE: *Physiol. Entomol.*

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SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135

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AFFILIATIONS: Centre for Visual Sciences, Research School of Biological Sciences, Australian National University, Canberra, Australia

ABBREVIATED SOURCE TITLE: *Philos. Trans. R. Soc. Lond., B, Biol. Sci.*

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Marcelja L., Jahnke R.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Marcelja, L. (6507668235); Jahnke, R. (57521576800)

7005370135; 6507668235; 57521576800

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AFFILIATIONS: Department of Neurobiology, Australian National University, Canberra, 2601, A.C.T., Box 475 P.O., Australia  
PUBLISHER: Springer-Verlag  
ABBREVIATED SOURCE TITLE: J. Comp. Physiol.  
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PUBLICATION STAGE: Final  
SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
7005370135  
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AFFILIATIONS: Australian National University, Australia  
PUBLISHER: Dadant and Sons, Inc  
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DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian National University, Canberra, ACT 2601, PO Box 475, Australia  
PUBLISHER: Elsevier Ltd  
ABBREVIATED SOURCE TITLE: J. INSECT PHYSIOL.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
OPEN ACCESS: All Open Access; Green Open Access  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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Pattern vision of the honeybee (*Lapis mellifera*): The effect of pattern on the discrimination of location  
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ABBREVIATED SOURCE TITLE: J. Comp. Physiol. A Sens. Neural. Behav. Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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The preferences of the honeybee (*Apis mellifera*) for different visual cues during the learning process

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ABBREVIATED SOURCE TITLE: J. Insect Physiol.

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SOURCE: Scopus

Butler R., Horridge G.A.

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7401524515; 7005370135

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AFFILIATIONS: Department of Neurobiology, Research School of Biological Sciences, Australian National University, Canberra, Australia; University Laboratory of Physiology, Oxford, OX1 3PT, United Kingdom

PUBLISHER: Springer-Verlag

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DOCUMENT TYPE: Article

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Lehrer M., Srinivasan M.V., Zhang S.W., Horridge G.A.

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DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

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ABBREVIATED SOURCE TITLE: *Physiol. Entomol.*

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PUBLICATION STAGE: Final

SOURCE: Scopus

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ABBREVIATED SOURCE TITLE: J. Comp. Physiol. A Sens. Neural. Behav. Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian National University, Canberra, ACT 2601, Australia

ABBREVIATED SOURCE TITLE: J. COMP. PHYSIOL. A SENS. NEURAL. BEHAV. PHYSIOL.

DOCUMENT TYPE: Article

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SOURCE: Scopus

Shelton P.M.J., Horridge G.A., Meinertzhagen I.A.

AUTHOR FULL NAMES: Shelton, Peter M.J. (7006774576); Horridge, G.A. (7005370135); Meinertzhagen, I.A. (59848995900)

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Reconstruction of synaptic geometry and neural connections from serial thick sections examined by the medium high voltage electron microscope

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ABBREVIATED SOURCE TITLE: Brain Res.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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(1998) *Journal of Insect Physiology*, 44 (3-4), pp. 343 - 350

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ABBREVIATED SOURCE TITLE: *J. Insect Physiol.*

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge A.

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DOI: 10.2147/EB.S70522

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PUBLISHER: Dove Medical Press Ltd.

ABBREVIATED SOURCE TITLE: *Eye Brain*

DOCUMENT TYPE: Article

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OPEN ACCESS: All Open Access; Gold Open Access; Green Open Access

SOURCE: Scopus

Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

7005370135

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AFFILIATIONS: Australian National University, Canberra, Australia

ABBREVIATED SOURCE TITLE: *New Sci.*

DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A., Henderson I.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Henderson, I. (7202588698)  
7005370135; 7202588698  
The ommatidium of the lacewing *Chrysopa* (Neuroptera)  
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AFFILIATIONS: Australia  
ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Barnes W.J., Horridge G.A.  
AUTHOR FULL NAMES: Barnes, W.J. (59877499500); Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: J Exp Biol  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Ioannides A.C., Horridge G.A.  
AUTHOR FULL NAMES: Ioannides, A.C. (7005049400); Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
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AFFILIATIONS: Australia

PUBLISHER: Elsevier Ltd

ABBREVIATED SOURCE TITLE: J. INSECT PHYSIOL.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

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ABBREVIATED SOURCE TITLE: J. Insect Physiol.

DOCUMENT TYPE: Review

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge A.

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(2009) *Journal of Experimental Biology*, 212 (17), pp. 2421 - 2729

DOI: 10.1242/jeb.030916

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ABBREVIATED SOURCE TITLE: J. Exp. Biol.

DOCUMENT TYPE: Review

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

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The evolution of visual processing and the construction of seeing systems  
(1987) Proceedings of the Royal Society of London - Biological Sciences, 230 (1260), pp.  
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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

McLean M., Horridge G.A.

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Structural changes in light- and dark-adapted compound eyes of the Australian earwig  
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DOI: 10.1016/0040-8166(77)90033-7

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ABBREVIATED SOURCE TITLE: Tissue Cell

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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ABBREVIATED SOURCE TITLE: UCLA Forum Med Sci

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Mimura K., Hardie R.C.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Mimura, K. (59793045200);  
Hardie, R.C. (7103309105)

7005370135; 59793045200; 7103309105

Fly photoreceptors; III. Angular sensitivity as a function of wavelength and the limits of  
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AFFILIATIONS: Australia

ABBREVIATED SOURCE TITLE: PROC. R. SOC. LONDON B BIOL. SCI.

DOCUMENT TYPE: Article

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Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
7005370135

How bees distinguish patterns by green and blue modulation

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DOI: 10.2147/EB.S89201

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PUBLISHER: Dove Medical Press Ltd.

ABBREVIATED SOURCE TITLE: Eye Brain

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

OPEN ACCESS: All Open Access; Gold Open Access; Green Open Access

SOURCE: Scopus

Horridge G.Adrian

AUTHOR FULL NAMES: Horridge, G.Adrian (7005370135)  
7005370135

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AFFILIATIONS: Australian Natl Univ, Canberra

PUBLISHER: Publ by IEEE

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DOCUMENT TYPE: Conference paper

PUBLICATION STAGE: Final

SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Australia

PUBLISHER: Royal Society

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DOCUMENT TYPE: Review

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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detectors: Observation versus theory

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SOURCE: Scopus

Horridge A.

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The Evolution of Pacific Canoe Rigs

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ABBREVIATED SOURCE TITLE: J. Pac. Hist.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Meinertzhagen I.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Meinertzhagen, I.A.  
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7005370135; 59848995900

The exact neural projection of the visual fields upon the first and second ganglia of the insect  
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AFFILIATIONS: Research School of Biological Sciences, Australian National University,  
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PUBLISHER: Springer-Verlag  
ABBREVIATED SOURCE TITLE: Z. Vergl. Physiol.  
DOCUMENT TYPE: Article  
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SOURCE: Scopus

Tsukahara Y., Horridge G.A.  
AUTHOR FULL NAMES: Tsukahara, Y. (7103255448); Horridge, G.A. (7005370135)  
7103255448; 7005370135  
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PUBLISHER: Springer-Verlag  
ABBREVIATED SOURCE TITLE: J. Comp. Physiol.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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(2000) Vision Research, 40 (19), pp. 2589 - 2603  
DOI: 10.1016/S0042-6989(00)00096-1  
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ABBREVIATED SOURCE TITLE: Vis. Res.  
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SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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AFFILIATIONS: Australian National University, Canberra, Australia  
PUBLISHER: Public Library of Science  
ABBREVIATED SOURCE TITLE: PLoS ONE  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
OPEN ACCESS: All Open Access; Gold Open Access; Green Open Access  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G. Adrian (7005370135)  
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ABBREVIATED SOURCE TITLE: Q. J. Exp. Physiol.  
DOCUMENT TYPE: Article  
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OPEN ACCESS: All Open Access; Bronze Open Access  
SOURCE: Scopus

Horridge A.  
AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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Visual resolution of the orientation cue by the honeybee (*Apis mellifera*)  
(2003) Journal of Insect Physiology, 49 (12), pp. 1145 - 1152  
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Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

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Pattern vision of the honeybee (*Apis mellifera*): Blue and green receptors in the discrimination of translocation

(2000) *Neurobiology of Learning and Memory*, 74 (1), pp. 1 - 16

DOI: 10.1006/nlme.1999.3939

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AFFILIATIONS: Centre for Visual Sciences, Res. School of Biological Sciences, Australian National University, Canberra, ACT 2601, P.O. Box 475, Australia

PUBLISHER: Academic Press Inc.

ABBREVIATED SOURCE TITLE: *Neurobiol. Learn. Mem.*

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Tsukahara Y., Horridge G.A.

AUTHOR FULL NAMES: Tsukahara, Y. (7103255448); Horridge, G.A. (7005370135)

7103255448; 7005370135

Miniature potentials, light adaptation and afterpotentials in locust retinula cells.

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[0017498190&partnerID=40&md5=c9d9817ddb98f440fd1a68481eeb65b1](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0017498190&partnerID=40&md5=c9d9817ddb98f440fd1a68481eeb65b1)

ABBREVIATED SOURCE TITLE: *J Exp Biol*

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

7005370135

Insects which turn and look

(1977) *Endeavour*, 1 (1), pp. 7 - 17

DOI: 10.1016/0160-9327(77)90004-7

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ABBREVIATED SOURCE TITLE: *Endeavour*

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

7005370135

Pattern discrimination by the honeybee (*Apis mellifera*): Training on two pairs of patterns alternately

(1999) *Journal of Insect Physiology*, 45 (4), pp. 349 - 355

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DOCUMENT TYPE: Article

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SOURCE: Scopus

Srinivasan M.V., Lehrer M., Kirchner W., Zhang S.W., Horridge G.A.

AUTHOR FULL NAMES: Srinivasan, M.V. (7203044676); Lehrer, M. (7006462837); Kirchner, W. (7006182850); Zhang, S.W. (59062608900); Horridge, G.A. (7005370135) 7203044676; 7006462837; 7006182850; 59062608900; 7005370135

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PUBLICATION STAGE: Final

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Horridge A.

AUTHOR FULL NAMES: Horridge, AdriAn (7005370135) 7005370135

Parallel inputs to memory in bee colour vision

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DOCUMENT TYPE: Article

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Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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PUBLISHER: Springer Verlag

ABBREVIATED SOURCE TITLE: *J. Comp. Physiol. A Sens. Neural. Behav. Physiol.*

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Butler R., Horridge G.A.

AUTHOR FULL NAMES: Butler, R. (7401524515); Horridge, G.A. (7005370135)

7401524515; 7005370135

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PUBLISHER: Springer-Verlag

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Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)

7005370135

Visual discriminations of spokes, sectors, and circles by the honeybee (*Apis mellifera*)

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ABBREVIATED SOURCE TITLE: J. Insect Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

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Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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PUBLICATION STAGE: Final

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Royal Aircraft Establishment, Farnborough

DOCUMENT TYPE: Article

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews  
DOCUMENT TYPE: Letter  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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Position of onset of fast phase in optokinetic nystagmus  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Zoology, University of St. Andrews  
DOCUMENT TYPE: Letter  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A., Barnard P.B.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Barnard, P.B. (35440693500)  
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Movement of palisade in locust retinula cells when illuminated.

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ABBREVIATED SOURCE TITLE: Q J Microsc Sci

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge A.

AUTHOR FULL NAMES: Horridge, Adrian (7005370135)  
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An Action Potential from the Motor Nerves of the Jellyfish *Aurellia aurita* Lamarck  
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AFFILIATIONS: Department of Zoology, University of Cambridge

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

OPEN ACCESS: All Open Access; Bronze Open Access

SOURCE: Scopus

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Relations between nerves and cilia in ctenophores

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DOI: 10.1093/icb/5.3.357

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[0005212681&doi=10.1093%2ficb%2f5.3.357&partnerID=40&md5=7a90c176a327a433f34ea5947483b433](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0005212681&doi=10.1093%2ficb%2f5.3.357&partnerID=40&md5=7a90c176a327a433f34ea5947483b433)

AFFILIATIONS: Gatty Marine Laboratory, St. Andrews, United Kingdom

ABBREVIATED SOURCE TITLE: Integr. Comp. Biol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

OPEN ACCESS: All Open Access; Bronze Open Access

SOURCE: Scopus

HORRIDGE G.A., SANDEMAN D.C.

AUTHOR FULL NAMES: HORRIDGE, G.A. (7005370135); SANDEMAN, D.C.

(59796900900)

7005370135; 59796900900

NERVOUS CONTROL OF OPTOKINETIC RESPONSES IN THE CRAB CARCINUS.

(1964) Proceedings of the Royal Society of London. Series B, Containing papers, 161, pp. 216 - 246

DOI: 10.1098/rspb.1964.0091

[https://www.scopus.com/inward/record.uri?eid=2-s2.0-](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0343065245&doi=10.1098%2frspb.1964.0091&partnerID=40&md5=d2a094a82e4f7035238b64ab25a6cb1b)

[0343065245&doi=10.1098%2frspb.1964.0091&partnerID=40&md5=d2a094a82e4f7035238b64ab25a6cb1b](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0343065245&doi=10.1098%2frspb.1964.0091&partnerID=40&md5=d2a094a82e4f7035238b64ab25a6cb1b)

ABBREVIATED SOURCE TITLE: Proc. R. Soc. Lond., B, Biol. Sci.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

7005370135

Perception of polarization plane, colour and movement in two dimensions by the crab, *Carcinus*

(1967) Zeitschrift für Vergleichende Physiologie, 55 (2), pp. 207 - 224

DOI: 10.1007/BF00342255

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[34250531280&doi=10.1007%2fBF00342255&partnerID=40&md5=98cb38966f0a51fd3ff3e46ab3ea2248](https://www.scopus.com/inward/record.uri?eid=2-s2.0-34250531280&doi=10.1007%2fBF00342255&partnerID=40&md5=98cb38966f0a51fd3ff3e46ab3ea2248)

AFFILIATIONS: Gatty Marine Laboratory and Department of Natural History, St. Andrews

PUBLISHER: Springer-Verlag

ABBREVIATED SOURCE TITLE: Zeitschrift für vergleichende Physiologie

DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
The flight of very small insects  
(1956) Nature, 178 (4546), pp. 1334 - 1335  
DOI: 10.1038/1781334a0  
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AFFILIATIONS: Gatty Marine Laboratory, St. Andrews  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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(1966) Journal of Experimental Biology, 44 (2), pp. 247 - 254  
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013895564&partnerID=40&md5=16fd6274dc0f50f6f3e4adc8fe5b5ec3>

ABBREVIATED SOURCE TITLE: J Exp Biol  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

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AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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(1966) Journal of Experimental Biology, 44 (2), pp. 233 - 245  
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013894795&partnerID=40&md5=1bad348155a6f5bb8aeb73cdb5fad36d>

ABBREVIATED SOURCE TITLE: J Exp Biol  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Armson J.M., Horridge G.A.  
AUTHOR FULL NAMES: Armson, J.M. (36748791900); Horridge, G.A. (7005370135)  
36748791900; 7005370135  
AN INVESTIGATION OF FACTORS OF CRUSTACEA  
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AFFILIATIONS: Gatty Marine Laboratory, University of St. Andrews, United Kingdom  
ABBREVIATED SOURCE TITLE: J. Neurochem.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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Pitch discrimination in orthoptera (insecta) demonstrated by responses of central auditory neurones  
(1960) Nature, 185 (4713), pp. 623 - 624  
DOI: 10.1038/185623a0  
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-13644260817&doi=10.1038%2f185623a0&partnerID=40&md5=a7ad1b1f8292742e413e6f01e1d28cc7>

AFFILIATIONS: Center for Advanced Study in the Behavioral Sciences, Stanford, CA  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
A note on the number of retinula cells of Notonecta  
(1968) Zeitschrift für Vergleichende Physiologie, 61 (2), pp. 259 - 262  
DOI: 10.1007/BF00341119  
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AFFILIATIONS: Gatty Marine Laboratory, University of St. Andrews, Fife, United Kingdom; Department of Natural History, University of St. Andrews, Fife, United Kingdom  
PUBLISHER: Springer-Verlag  
ABBREVIATED SOURCE TITLE: Z. vergl. Physiologie  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
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DOI: 10.1007/BF00298040

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[0005141666&doi=10.1007%2fBF00298040&partnerID=40&md5=c74825d213a414179ae273a24fd2087c](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0005141666&doi=10.1007%2fBF00298040&partnerID=40&md5=c74825d213a414179ae273a24fd2087c)

AFFILIATIONS: Gatty Marine Laboratory and Department of Natural History, University of St. Andrews, United Kingdom

PUBLISHER: Springer-Verlag

ABBREVIATED SOURCE TITLE: Z. Vergl. Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Tamm S.L.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Tamm, S.L. (59115415900)  
7005370135; 59115415900

Critical point drying for scanning electron microscopic study of ciliary motion

(1969) Science, 163 (3869), pp. 817 - 818

DOI: 10.1126/science.163.3869.817

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[0346858304&doi=10.1126%2fscience.163.3869.817&partnerID=40&md5=4df120324109dc b4ee76e004a4d97ec3](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0346858304&doi=10.1126%2fscience.163.3869.817&partnerID=40&md5=4df120324109dc b4ee76e004a4d97ec3)

AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews, St. Andrews, United Kingdom; Department of Zoology, Indiana University, Bloomington, IN, United States

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Tunstall J., Horridge G.A.

AUTHOR FULL NAMES: Tunstall, J. (16539479700); Horridge, G.A. (7005370135)  
16539479700; 7005370135

Electrophysiological investigation of the optics of the locust retina

(1967) Zeitschrift für Vergleichende Physiologie, 55 (2), pp. 167 - 182

DOI: 10.1007/BF00342252

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[0344025024&doi=10.1007%2fBF00342252&partnerID=40&md5=5fe4b3490968ded80ffa3d c3bfb0e189](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0344025024&doi=10.1007%2fBF00342252&partnerID=40&md5=5fe4b3490968ded80ffa3d c3bfb0e189)

AFFILIATIONS: Gatty Marine Laboratory and Department of Natural History, University of St. Andrews, United Kingdom; Department of Biology, Queen Elizabeth College, London, United Kingdom

PUBLISHER: Springer-Verlag

ABBREVIATED SOURCE TITLE: Zeitschrift für vergleichende Physiologie

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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Affinity of neurones in regeneration [25]  
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DOI: 10.1038/219737a0  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews  
DOCUMENT TYPE: Letter  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A., Shephard P.R.B.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Shephard, P.R.B. (59123765100)  
7005370135; 59123765100  
Perception of movement by the crab  
(1966) Nature, 209 (5020), pp. 267 - 269  
DOI: 10.1038/209267a0  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Zoology, University of St. Andrews  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
OPEN ACCESS: All Open Access; Bronze Open Access  
SOURCE: Scopus

Hámori J., Horridge G.A.  
AUTHOR FULL NAMES: Hámori, J. (57215975488); Horridge, G.A. (7005370135)

57215975488; 7005370135

The lobster optic lamina. 3. Degeneration of retinula cell endings.

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[0013942785&partnerID=40&md5=14319d543b47dda3191e9b50e0de49e4](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013942785&partnerID=40&md5=14319d543b47dda3191e9b50e0de49e4)

ABBREVIATED SOURCE TITLE: J Cell Sci

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

7005370135

A direct response of the crab carcinus to the movement of the sun [38]

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[0011443197&doi=10.1038%2f2071413a0&partnerID=40&md5=61824c339e8d14db9b7862390d57d8fa](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0011443197&doi=10.1038%2f2071413a0&partnerID=40&md5=61824c339e8d14db9b7862390d57d8fa)

AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews

DOCUMENT TYPE: Letter

PUBLICATION STAGE: Final

SOURCE: Scopus

HORRIDGE G.A.

AUTHOR FULL NAMES: HORRIDGE, G.A. (7005370135)

7005370135

Comparative physiology: integrative action of the nervous system.

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DOI: 10.1146/annurev.ph.25.030163.002515

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[73649195323&doi=10.1146%2fannurev.ph.25.030163.002515&partnerID=40&md5=1ac46431cf70533c8297ca713e3d8ef9](https://www.scopus.com/inward/record.uri?eid=2-s2.0-73649195323&doi=10.1146%2fannurev.ph.25.030163.002515&partnerID=40&md5=1ac46431cf70533c8297ca713e3d8ef9)

ABBREVIATED SOURCE TITLE: Annu. Rev. Physiol.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A., Roberts M.B.V.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Roberts, M.B.V. (56327377100)

7005370135; 56327377100

Neuro-muscular transmission in the earthworm

(1960) Nature, 186 (4725), pp. 650 - 651

DOI: 10.1038/186650a0

<https://www.scopus.com/inward/record.uri?eid=2-s2.0-36949078973&doi=10.1038%2f186650a0&partnerID=40&md5=1e23aa5ee6f9b3b377293f2caac03b64>

AFFILIATIONS: Gatty Marine Laboratory, Sf. Andrews, Fife; Biology Department, Marlborough College, Wiltshire  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
The eye of *Dytiscus* (Coleoptera)  
(1969) *Tissue and Cell*, 1 (3), pp. 425 - 442  
DOI: 10.1016/S0040-8166(69)80015-7  
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AFFILIATIONS: School of Biological Sciences, Canberra City, Australian Capital Territory, 2601, P.O. Box 475, Australia  
ABBREVIATED SOURCE TITLE: *Tissue Cell*  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A., Chapman D.M., Mackay B.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135); Chapman, D.M. (57196527103); Mackay, B. (23057390900)  
7005370135; 57196527103; 23057390900  
Naked axons and symmetrical synapses in an elementary nervous system  
(1962) *Nature*, 193 (4818), pp. 899 - 900  
DOI: 10.1038/193899a0  
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AFFILIATIONS: Gatty Marine Laboratory, Department of Zoology, St. Andrews; Department of Zoology, Cambridge; Department of Anatomy, Edinburgh  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
Intracellular action potentials associated with the beating of the cilia in ctenophore comb plate cells [24]  
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DOI: 10.1038/205602a0

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AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St. Andrews

DOCUMENT TYPE: Letter

PUBLICATION STAGE: Final

OPEN ACCESS: All Open Access; Bronze Open Access

SOURCE: Scopus

HORRIDGE G.A.

AUTHOR FULL NAMES: HORRIDGE, G.A. (7005370135)

7005370135

Analysis of the rapid responses of Nereis and Harmothoë (Annelida).

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[0343445018&partnerID=40&md5=ab7a225e887097b764f8e67e00b7e9ec](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0343445018&partnerID=40&md5=ab7a225e887097b764f8e67e00b7e9ec)

ABBREVIATED SOURCE TITLE: Proc. R. Soc. Lond., B, Biol. Sci.

DOCUMENT TYPE: Article

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

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A through-conducting system co-ordinating the protective retraction of Alcyonium (coelenterata) [26]

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DOI: 10.1038/1781476b0

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[36949076627&doi=10.1038%2f1781476b0&partnerID=40&md5=2f356dd0e7321df7e012eefb5f18e560](https://www.scopus.com/inward/record.uri?eid=2-s2.0-36949076627&doi=10.1038%2f1781476b0&partnerID=40&md5=2f356dd0e7321df7e012eefb5f18e560)

AFFILIATIONS: Gatty Marine Laboratory, St. Andrews

DOCUMENT TYPE: Letter

PUBLICATION STAGE: Final

SOURCE: Scopus

Horridge G.A.

AUTHOR FULL NAMES: Horridge, G.A. (7005370135)

7005370135

Adaptation and other phenomena in the optokinetic response of the crab, Carcinus.

(1966) Journal of Experimental Biology, 44 (2), pp. 285 - 295

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[0013894449&partnerID=40&md5=14123aa72a2f89ed10cc0afdf84dc8c8](https://www.scopus.com/inward/record.uri?eid=2-s2.0-0013894449&partnerID=40&md5=14123aa72a2f89ed10cc0afdf84dc8c8)

ABBREVIATED SOURCE TITLE: J Exp Biol  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Horridge G.A.  
AUTHOR FULL NAMES: Horridge, G.A. (7005370135)  
7005370135  
Statocysts of medusae and evolution of stereocilia  
(1969) Tissue and Cell, 1 (2), pp. 341 - 353  
DOI: 10.1016/S0040-8166(69)80029-7  
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-1542520343&doi=10.1016%2fS0040-8166%2869%2980029-7&partnerID=40&md5=8b70e1c0e27eb5f8f6b77221da81d289>

AFFILIATIONS: Gatty Marine Laboratory, Department of Natural History, University of St Andrews, St Andrews, Fife, United Kingdom  
ABBREVIATED SOURCE TITLE: Tissue Cell  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

BROCH H., HORRIDGE A.  
AUTHOR FULL NAMES: BROCH, HJALMAR (16648604900); HORRIDGE, ADRIAN (7005370135)  
16648604900; 7005370135  
A NEW SPECIES OF SOLENOPODIUM (STOLONIFERA: OCTOCORALLIA) FROM THE RED SEA  
(1957) Proceedings of the Zoological Society of London, 128 (2), pp. 149 - 160  
DOI: 10.1111/j.1096-3642.1957.tb00263.x  
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AFFILIATIONS: The Zoological Laboratory, Oslo, Blindern, Norway; Gatty Marine Laboratory, St. Andrews, United Kingdom  
ABBREVIATED SOURCE TITLE: J. Zool.  
DOCUMENT TYPE: Article  
PUBLICATION STAGE: Final  
SOURCE: Scopus

Hámori J., Horridge G.A.  
AUTHOR FULL NAMES: Hámori, J. (57215975488); Horridge, G.A. (7005370135)  
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Bennett R.R., Tunstall J., Horridge G.A.

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ABBREVIATED SOURCE TITLE: Symp Soc Exp Biol

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SOURCE: Scopus

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Multimodal interneurons of locust optic lobe [42]

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