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Shirley Winifred Jeffrey 1930–2014*

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Australian scientist Shirley Jeffrey was a pioneer in oceanographic research, identifying the then-theoretical chlorophyll *c*, and was a worldwide leader in the application of pigment methods in quantifying phytoplankton as the foundation of the oceanic food supply. Her research paved the way for the successful application of microalgae in aquaculture around the world. Jeffrey earned bachelor's and master's degrees at University of Sydney, majoring in microbiology and biochemistry, followed by a PhD from the King's College London Hospital Medical School. Returning to Sydney, she was hired by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to research chlorophyll *c*. Following this successful effort, she became a research fellow at the University of California, Berkeley from 1962 to 1964. She then became affiliated with the Scientific Committee on Oceanic Research. After a 1973 sabbatical at the Scripps Institution of Oceanography in San Diego, she returned to CSIRO, where she spent the rest of her career.

Introduction

At her induction into the National Academy of Sciences as a foreign associate, Shirley W. Jeffrey was introduced by her colleague, Professor Andrew Benson, as the 'Mother of Chlorophyll *c*,' reflecting her pre-eminence in algal chlorophyll research. Shirley pioneered the use of chlorophylls and carotenoids as quantitative markers for analysis of ocean phytoplankton communities, and she led the field for most of her life, as well as fostering the use of microalgae in mariculture—the branch of aquaculture conducted in the open ocean. She had an extraordinary thirst for scientific discovery, focusing on her beloved phytoplankton, the microalgae that form the base of marine food webs. She made fundamental contributions to the field, including many classic papers that have underpinned algal phylogeny and chemotaxonomy. She had the highest possible scientific standards, but her razor-sharp logic and relentless striving for excellence was counterbalanced by personal humility and a deep sense of compassion for other people, often expressed in the spirituality and poignancy of her violin playing.

Early Life

Shirley Winifred Jeffrey was born in Townsville, Queensland, Australia, on 4 April 1930, of English parents. She was one of three sisters (with Elizabeth and Ann) and had a brother, Tom. Her father was an oil company executive who was willing to move around in order to further his career. As a result, Shirley attended 14 different schools—normally a challenging start in the quest for a career. But her strongly positive

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Figure 1. Young Shirley.

outlook and her desire to achieve goals and contribute to society led Shirley to career success and considerable achievements. Even as a Girl Guide, Shirley went after every badge.

Her most positive school experience was at the Methodist Ladies College (MLC), Melbourne, which she attended from 1942 to 1946 with 1800 other girls and which she described as a 'marvelous school'.[1] Following the girls' preference for using surnames, Shirley was known as 'Jeff.' She was good at field hockey but generally hated physical education. Her school friend Glen Rose remembers Shirley as a happy girl, quiet, thoughtful and self-effacing (Fig. 1). While at MLC Shirley became inspired with the wonder of the natural world—in particular, the function of cells and the animal body. Her chief inspiration was her science teacher, Connie Glass.

Two books played a pivotal role in Shirley's early development—the biography of Marie Curie (by her daughter Ève Curie) and the biography of Mother Teresa, which Shirley apparently kept with her at all times. These women became her heroines, and it is easy to see in retrospect how she carried their ideals into her scientific career and her personal life.

Shirley was also a proficient violinist, and music played a major role throughout her life. While at MLC, Shirley auditioned for and was accepted by the Victorian Youth Orchestra, but even before her first rehearsal the family moved to Sydney, so she couldn't take up the offer. She was deeply disappointed.

The move to Sydney raised a further hurdle for her transition to university, for although she was inspired by science, her new school had no facilities for science teaching at that time. Shirley studied mathematics, English, French and German but had no university science prerequisites. She was able to attend tutorials in science at University of Sydney before enrolling there as a student, but she still found it very difficult to catch up during her first year.

Shirley majored in microbiology and biochemistry and made steady progress toward her goal of a career in science. She was inspired by Professor Jack Still, who 'opened up …the wonder of the functioning of individual cells in an animal or a plant'.[2]

She graduated with a BSc in 1952 and then went on to an MSc degree in 1954, studying the metabolism of oyster sperm cells under the supervision of Dr George Humphrey, who became an important mentor for her. Shirley then moved to London, UK, where she earned a PhD in 1958, determining the effect of aspirin on carbohydrate metabolism under the supervision of Dr M. J. H. Smith at King's College London Hospital Medical School.

Early Career

Upon returning to Australia, Shirley rejoined Dr Humphrey, who by then had been appointed chief of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Fisheries and Oceanography at Cronulla, Sydney. For several years marine scientists had suggested that some marine algae contained not only the well-known chlorophylls *a* and *b*, but also a third, chlorophyll *c*. In 1958, Humphrey advertised for a research scientist to solve the mystery. Shirley was the best of 12 applicants, and the rest is history.

She concentrated on chromatographic pigment-separation techniques, starting with paper, column and thin-layer chromatography (TLC) and ultimately, in the 1990s, pursuing high-performance liquid chromatography (HPLC) with the senior author of this biography (SWW). Shirley also drew attention to the occurrence of chlorophyll *b* at the chlorophyll maximum in the North Pacific Central Gyre, first identified with thin-layer chromatography[3] and later confirmed with HPLC.

The results from her first attempt of purification of chlorophyll *c* from the brown seaweed *Sargassum* appeared in 1962 as a note in *Nature*.[4] She then worked as a research fellow in the marine photosynthesis laboratory of Dr Mary Bell Allen in Berkeley (1962–4), characterizing for the first time the pigments of the haptophyte *Emiliania huxleyi*. She revisited the pigments of this species numerous times in her career.

While at Berkeley, she met fellow post-docs, including a young German, Hartmut Lichtenthaler, who later led major advances in the photosynthetic physiology and biochemistry of chloroplasts of higher plants. Hartmut recalled:

> Our joint time more than fifty years ago in Berkeley together with other young postdocs was a wonderful time in our lives. In the early 1960s, the scientific world was wide open for us. With new methods of investigation, advanced scientific instruments, and new chromatographic techniques (e.g. radio-labelling of cellular metabolites, electron microscopy, sensitive recording two-wavelength spectrophotometers, TLC), one could start almost in any field and make large scientific progress. We all were enlightened by the then great 'Berkeley spirit' to dedicate our life to science and to try to make basic, essential and innovative contributions. It was an atmosphere of departure! And this 'Berkeley spirit' kept us busy in science over the last five decades. It was a lifelong commitment for Shirley and me and many others who were postdocs in Berkeley at that time. All of us coming from different nations felt then that we were belonging to a worldwide international science family. And this knowledge led to life-long personal contacts and to a continuous international scientific cooperation that was the essential basis of the large progress made in plant and marine biology in the last five decades.

In 1964, Shirley began a lifelong association with the oceanography world's premier scientific advisory body, the Scientific Committee on Oceanographic Research (SCOR), when she was invited to the first ever SCOR pigment workshop, held at UNESCO in Paris. This resulted in the much-cited SCOR manual for oceanographers setting out the 'trichromatic' spectrophotometric method for determining chlorophylls *a*, *b* and *c* in pigment extracts of phytoplankton.[5] Thanks to the use of spectrophotometric and related fluorometric methods, chlorophyll soon became the most frequently measured ecological variable in oceanography.

Shirley continued work on chlorophyll *c* using a new chromatographic medium—polyethylene powder that she brought back from Berkeley. She separated two new chlorophyll *c* fractions, designated c_1 and c_2, in 1968,[6] then described their properties,[7] and surveyed their taxonomic distribution in various classes of algae.[8] Her later work with Australian and Spanish collaborators ultimately revealed a suite of at least 9 chlorophyll c fractions, particularly in the Haptophyta. These included the discovery of chlorophyll c_3,[9] and its chemical characterization,[10] as well as the non-polar chlorophyll c_2 monogalactosyldiacylglyceride ester with a massive lipid side chain.[11]

A chance invitation in 1966 to join the maiden voyage of the Scripps Institution of Oceanography vessel *Alpha Helix* to the Great Barrier Reef brought her into contact with Professors Francis Haxo (Scripps), Kazuo Shibata (University of Tokyo) and Per Halldal (University of Oslo) working on pigments of what were then phylogenetically unknown zooxanthellae from corals and clams. Their pigments appeared to be identical to those of cultured plankton dinoflagellates that contain the carotenoid peridinin, in addition to chlorophylls *a* and *c*, diadinoxanthin, and several minor carotenoids. Peridinin was isolated in bulk, crystallized, and its extinction coefficients in various solvents established. A spectrophotometric study with Shibata on chlorophyll *c* from zooxanthellae of the giant clam *Tridacna* established an important baseline for future studies.[12] This Coral Sea cruise led to an invitation to Shirley in 1973 for a sabbatical in Professor Andrew Benson's laboratory at Scripps in California, where she studied violaxanthin carotenoid transformations in the spinach chloroplast envelope.

Figure 2. Shirley and Andy.

Andy Heron

About this time, Shirley got to know the love of her life, Dr Andy Heron, a kind, gentle man who was an expert in salps and other pelagic tunicates (gelatinous marine animals). They met at CSIRO in Cronulla, but it was during her 1973 sabbatical at Scripps that their romance blossomed. They were married on 24 November 1973, at Watsons Bay in Sydney. Andy gave her a wedding ring containing an emerald the colour of chlorophyll *c*. He was a great support to Shirley, particularly through his expertise with mathematics and computers. Their time together was very happy, but all too short—tragically, Andy died in 1989 (aged only 49) after weeks in a coma following complications from a heart valve infection. Shirley was shattered and took at least two years to re-emerge. Nevertheless, their very special relationship sustained her all the rest of her life (Fig. 2).

Back at CSIRO

Having succeeded in the difficult job of producing pure chlorophyll pigments, Shirley was well aware that existing spectrophotometric equations for chlorophylls had to be corrected. While her boss, Dr Humphrey, was away on one of his many overseas trips, Shirley decided to publish the equations. She wrote the paper, had it rejected by three journals (reputedly because it lacked a connection to its biological implications), but ultimately had the manuscript accepted by the little-known East German journal *Biochemie und Physiologie der Pflanzen*.[13] This classic has attracted over 3000 citations, which is a remarkable achievement for a microalgal publication and serves as an encouragement for young authors who have their early papers rejected. Following this success, in 1978 Shirley visited Carl J. Lorenzen at the University of Washington and co-authored the first UNESCO report on pigment intercalibration.

A CSIRO decision in the 1970s to set up a new Marine Biochemistry Unit, initially in the Botany Department of University of Sydney, led Shirley to a successful collaboration with electron microscopist Dr Maret Vesk, working on blue-light effects on microalgal ultrastructure. New electron microscope techniques also produced spectacular improvements in phytoplankton taxonomy, as pursued in 1978 by Shirley and

Figure 3. Shirley and the CSIRO team, 1989. (Left to right) Shirley, Gustaaf Hallegraeff, Duyet Lee, Chris Bolch, Sue Blackburn, Malcolm Brown, Grahame Kelly, Jeannie-Marie LeRoi.

Dutch postdoc Gustaaf Hallegraeff, who came to Australia to visit for ten months, never left, and now is a professor at the Institute for Marine and Antarctic Studies of the University of Tasmania (Fig. 3).

A major legacy from these collaborations started in 1971 as a small microalgal culture collection held at the CSIRO Marine Biochemistry Unit of University of Sydney that comprised some 80 species by the time it was transferred to the CSIRO Division of Fisheries and Oceanography laboratories in Cronulla in 1977. Over time Shirley's research collection has grown into the Australian National Algae Culture Collection, which now contains over 1000 strains of more than 300 species and is currently maintained by Dr Sue Blackburn at the Hobart Laboratories of CSIRO Marine and Atmospheric Research. The collection is a resource for research into biofuels and bioactive molecules such as algal toxins, provides pigment reference material and supplies starter cultures to the Australian aquaculture industry.

Acting Chief of Fisheries

Shirley reluctantly took on the role of acting chief of the CSIRO Division of Fisheries from 1981 to 1984, which involved overseeing the tumultuous relocation of the Division from Cronulla to new laboratories in Hobart. Several staff mentioned that Shirley's personal care in managing the move greatly alleviated the stress of this upheaval.

As acting chief, Shirley fostered several strategic programs of ongoing benefit to Australian science and industry. For instance, she urged Dr Peter Rothlisberg to look at a new initiative called aquaculture, and she stimulated collaborations with lipid biochemist Dr John Volkman, aquaculture hygienist Dr Christian Garland and biochemist Dr Malcolm Brown to service the Australian mariculture industry with nutritionally reliable microalgal feed cultures. These programs were significant contributions to the Australian aquaculture industry—as recognized in the etymology of *Naviculajeffreyae*, a diatom feed culture used for abalone.[14]

SCOR-UNESCO Monographs

In the 1980s, HPLC was successfully applied to separate, identify and quantify over 40 chlorophyll and carotenoid pigments and degradation products in phytoplankton and seawater samples.[15,16] As a result, a new SCOR-UNESCO working group chaired by R. Fauzi C. Mantoura

Figure 4. CSIRO pigment workshop, 1988. (Left to right) Carole Llewellyn, Fauzi Mantoura, Shirley, Simon Wright, Nick Welschmeyer.

was set up in 1985 to intercalibrate and standardize pigment HPLC protocols for routine application in oceanography and phytoplankton ecology. Shirley was invited to join this group, initially to ensure coherency with past SCOR activities and with marine phycology. There followed three experimental and five writing workshops (in Hobart and in Plymouth, UK) involving 20 specialists from nine countries, during which, in spite of Shirley's bereavement during this time, she meticulously and patiently nurtured and led the work to publication.[17] The monograph was an outstanding peer-reviewed *magnum opus* of 661 pages entitled *Phytoplankton Pigments in Oceanography*.

During the Hobart workshops, Shirley would shepherd bleary-eyed scientists and technicians to an 8 a.m. start, followed by intense periods analysing samples in the laboratory, under the microscope, in cold culture rooms, and on board CSIRO vessels. The atmosphere was intense, focused and frenetic. By mid-afternoon the exhausted troops would be invited to her home in the Hobart suburb of Sandy Bay for a quick round of tennis, followed by an early evening sweetener performed on Shirley's violin, then rewarded with grilled barramundi and Tasmanian chardonnay at one of the restaurants on Hobart's bustling Salamanca Place. Her leadership was inspirational and fun (Fig. 4).

Shirley had insisted the monograph be accessible, affordable and usable by scientists from the developing world, and so she persuaded her co-authors to forgo their fees and for UNESCO to sell it at US$50 per copy. The first print run of 2000 copies sold out within 18 months, necessitating a rerun of 500 copies in 2005, which sold out within two years. Although Shirley would have been delighted that her monograph has attracted over 1000 publications to date, she would have been rather embarrassed that it is widely known as the 'Pigment Bible' and that second-hand versions are today on sale for US$600!

Figure 5. Shirley with microalgal culture.

In 2011, a second volume was published that covered new advances.[18] Although Shirley was not able to be an editor, she was heavily involved in advising the new editors and in reviewing chapters. This volume was dedicated to Shirley, acknowledging her pioneering role in the field, and she was deeply touched by this.

Personal Life

At Shirley's memorial service at the Australian Academy of Science in February 2014, her sister, Ann, read a quote from Marie Curie that had been important to Shirley: 'Life is not easy for any of us. But what of that? We must have perseverance and, above all, confidence in ourselves. We must believe that we are gifted for something, and this thing, at whatever cost, must be obtained.' It is clear that this attitude drove her scientific career, while the faith, humility and generosity of Mother Teresa motivated her personally. Shirley's two heroines shared a fervent desire for excellence and dedication to the betterment of humankind, but possibly the differences in their paths explain some of the complexity of Shirley's life.

Shirley had the highest possible standards as a scientist: perfection, to her, was not an aspiration but a requirement. She was resolute in her insistence on accuracy in research and writing. Experiments, she held, must be repeated until shown to be irrefutable (Fig. 5). Nothing was to be published that wasn't checked and rechecked and guaranteed to be correct. For example, during compilation of the new pigment monograph Shirley was asked if she could provide an extinction coefficient for astaxanthin, an important phytoplankton pigment that is used in aquaculture and food colouring. She spent three weeks tracking down a reliable value from the literature after discovering that the normally cited value had not been experimentally derived even though it was routinely used in several fields.[19]

While Shirley's drive and perfectionism produced excellent science, it must be acknowledged that she was not always easy to work with, for it was very difficult to match her commitment to the task at hand, her thoroughness and her standards. She was driven to achieve, and she assumed that staff and collaborators were similarly driven. Normal work hours simply did not exist for her—weekends and public holidays passed unnoticed or were marked by picnics at work in the CSIRO library (because the cafeteria was closed). There was ONE way to do things, the RIGHT way, HER way. So one needed patience; but such was her focus and the basis for her success that all who worked with her benefited from her example, however

intimidating, of how such focus and drive could produce significant advances.

Shirley's disregard of normal work hours also applied to her seminars, as she was legendary for going overtime. She had a story and it must be told, completely, in detail. Nor did the confines of her office limit her activities. Her book and reprint collection gradually took over the laboratory corridor until it was deemed a health and safety hazard. So Shirley set up operations on a desk (or several) in the CSIRO library, where she sat with her tartan rug, surrounded by piles of papers, each labelled and tied with a ribbon—which the library staff kindly ignored as these documents gradually spread across the library floor.

But this is only part of the story, for behind that drive Shirley was very kind-hearted and inspirational. She never lost her sense of wonder in nature and appreciation of beauty in the natural world. She inspired those around her with her enthusiasm and sense of the work's importance, so that one wanted to match her timetable and her standards. She was generous of spirit, genuinely interested in other people—from the cleaners and gardeners to the most eminent scientists and leaders—and in colleagues' research. She would regularly inquire how things were going, offer advice and encouragement, and seek people out to congratulate them on successes. Anyone who met Shirley will remember her warmth, sparkly eyes and joyous smile.

Shirley was also extremely generous with her own time and money toward education and charity, perhaps following Mother Teresa's example. She was a fellow and a council member at Jane Franklin Hall, a residential college of the University of Tasmania, where she regularly advised and mentored students. She was also an officer of the Royal Society of Tasmania and often hosted their events in the CSIRO auditorium.

Shirley was an inspiration to many female scientists as a role model, for she built her career at a time when discrimination against women was common in science. In an interview, Shirley said that she didn't think she had experienced discrimination, but in this she was probably downplaying the situation. She added, 'When I started publishing my work as a young scientist, it was the convention for women to use their full first names so that their sex would be clear. I thought, 'Why should sex come into it?' so I always used my initials. And it did take people a long time before they found out that I was not a man!'[20] But she would have been well aware of the considerable prejudice encountered by Marie Curie, so signing her papers as S. W. Jeffrey was probably a calculated strategy. She once confided that the first time she went to England, the professor she was visiting refused to see her when he realized that S. W. Jeffrey was the girl in the red raincoat. So discrimination was alive and well at this time. But it is clear that Shirley succeeded due to the excellence of her science, regardless of whether her gender was known.

In spite of overcoming such discrimination, Shirley was not completely liberated herself. She was a child of her time in this regard and unconsciously divided the world into things that men could do and things that women could do. This was a regular source of frustration to her female staff and colleagues, but it also limited her. In particular, in spite of her prodigious technical ability, she never came to grips with computers and word processing. As a result, she handwrote all of her papers, used real cut-and-paste (or staples) to edit, and then passed them to a typist for word processing, even though she was a very competent typist herself. She managed emails out of necessity and sometimes typed text and emailed it to herself to save it. Lesley Clementson, in the next office, tried on several occasions to teach Shirley to use Microsoft Word, and even set up templates for her, but Shirley just didn't seem to believe that she could learn it.

Music continued to play a huge part in Shirley's life. She regularly played concerts as second violin with the Hobart Chamber Orchestra, for which she was also the secretary and organizer for many years. She owned and treasured a beautiful 1775 Antonio Gragnani violin (now donated to the Australian Chamber Orchestra). She also regularly attended concerts of the Tasmanian Symphony Orchestra.

Shirley was always fit and active. She enjoyed regular bushwalks, and she was a keen tennis player with a mean serve well into her seventies. But her physical health was shattered in 2011, when she fell down the stairs in the dark during a power blackout and broke her hip and pelvis. She was living alone, and it took her an hour to raise the neighbours, using her shoe to bang on the door, initially trying SOS in Morse code

(recalling her Girl Guide days), but eventually banging out musical patterns. After being told that she would be in hospital for three months, Shirley immediately took a large notepad, created a calendar, and mapped out a timetable for her recovery period. This was a classic Shirley response—and she kept to her timetable.

Fortunately, at this time several of her collaborators prepared a tribute to her career. Ten years earlier, around Shirley's 70th birthday, they considered (as scientists do) creating a journal volume dedicated to her, featuring contributions by her collaborators. Of course, they were duly nervous about doing so. Not only would it never be good enough, but when they tactfully sought her approval she did not want to have a bar of it lest people think she had retired. (She had actually formally retired at age 65 during preparation of the SCOR UNESCO volume, due to CSIRO policy, but she didn't tell anyone—nor did she ever consider herself retired). Around her 80th birthday, when she was becoming increasingly frail, her collaborators secretly revived this idea but realized they had to hurry, and so the idea of publishing a tribute in a scientific journal was born. When they first sought the blessing of a journal editor, the response was 'but she is not dead' and 'you missed her 80th birthday', which they circumvented by calling the article '50 years of research on chlorophyll *c*,' thus celebrating her 1962 *Nature* publication. The tribute was published the week she turned 82,[21] and presented to her at a surprise dinner party at a Hobart restaurant. While the dinner guests' coffees were turning cold, she quietly read the tribute in full with tears in her eyes. 'The Lady approved, we finally got it right.' (G. M. Hallegraeff, speaking at Shirley's funeral.)

This was very timely because shortly after this, Shirley was diagnosed with cancer of the mouth. She endured a major operation and radiation therapy, but continually declined until her death in January 2014. She was very courageous during this battle and never lost her sense of humour. During this time she was supported by family and friends, but the dedicated aid of her colleague Dr Lesley Clementson should be acknowledged in particular, for she visited Shirley and ran errands for her practically every day for well over a year.

Many close colleagues were surprised to learn that Shirley had a strong religious faith. Her brother, Tom, related that after talking about the amazing forms of microalgae seen under an electron microscope, she said, 'How could one not believe in God?' Shirley's faith supported her all her life, particularly in her final years. Close to death, she mentioned that she was comforted by her belief that she would be with Andy again. But her faith was not uncritical—at her funeral the minister said that Shirley had read many religious texts in her final months and had subjected each to a detailed analytical critique.

In true fashion, Shirley organized much of her own funeral. It was held at St George's Church, Battery Point, Tasmania, which had also been the site of Andy's funeral. It was a very musical event: The 16-piece Hobart Chamber Orchestra played Vaughan Williams' *Rhosymedre*, as well as Bach's *Pastorale* and *Jesu Joy of Man's Desiring*, with Lucy Carrig-Jones (principal second violinist of the Tasmanian Symphony Orchestra and Shirley's teacher and music mentor) playing Shirley's cherished violin. Biblical texts related mainly to helping the unfortunate, which the minister noted was unusual. Some two hundred people celebrated Shirley's life and achievements.

Shirley's Legacy

Those of us who were fortunate enough to have known and worked closely with Shirley will never forget her passion for science, her rigor and her drive. She was a creative and strategic thinker who exemplified the highest standards, yet was warm, caring and humble. Clearly she never wavered from her goals and standards, as exemplified by Marie Curie and Mother Teresa.

We may ask in turn, 'What did Shirley teach us about science and life? What would Shirley want us to say here?' First of course, would be her commitment to accuracy, what she called 'the purity of the scientific literature'. Second, our writing should 'read like a symphony', meaning that it should be balanced, graceful, and coherent. Third, we should 'think of the third world reader', meaning that we should use clear, simple text for readers with English as a second language. But more generally, the vocabulary and structure of text should make the information easily accessible. Finally, we should see the beauty in life.

These were Shirley's mantras, which she rigorously applied to her science, producing a huge

volume of superb work across several fields. She set standards for scientific research to which we should all aspire. She will be sadly missed, but her ethos and legacy live on in colleagues to inspire a new generation of phycologists and oceanographers.

Awards

Shirley led the way as a scientist, a woman and a mentor, and she was recognized with numerous awards. She received the 1988 inaugural Jubilee Award from the Australian Marine Science Association. CSIRO made her a chief research scientist in 1991, and in the same year she became a fellow of the Australian Academy of Science. In 1993, she was made a member of the Order of Australia. In 2000, Shirley received the Gilbert Morgan Smith Medal from the USA National Academy of Sciences, the first person outside the USA to receive this award, and she was elected a foreign associate of the Academy in 2001. In 2003, she was awarded the Australian Centenary Medal, and in 2007 she received the Shinkishi Hatai Medal at the 21st Pacific Science Congress in Okinawa, Japan. In February 2015, the Reflection Room at Jane Franklin Hall was dedicated to Shirley's memory, with a display of Shirley's awards as well as a large portrait of her at her microscope.

Select Bibliography

A select bibliography of scientific publications by Shirley Winifred Jeffrey is available online as Supplementary Material to this paper.

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