Phytochemistry 69 (2008) 3015–3017

Contents lists available at ScienceDirect

Phytochemistry

journal homepage: www.elsevier.com/locate/phytochem

Obituary

William Edwin (Ted) Hillis (1921–2008): A Pioneer in the Study of (Heart)wood Formation and their Constituents

William Edwin (Ted) Hillis

(1921 – 2008)

In this special issue of *Phytochemistry* devoted to Tannins/Polyphenols, we sadly remember the passing of Ted Hillis on 3 February 2008, just six days before his 87th birthday. His long and highly productive scientific career spanned nearly seven decades; during that time, Ted made enormous contributions to phytochemistry and related areas, that are of worldwide importance and lasting significance. He was also involved early on in helping establish *Phytochemistry*, both during and following the time when he worked with Edgar C. Bate-Smith and Tony Swain in 1956 at Cambridge University. For the readership today, he is best known though for the truly pioneering studies he made as regards heartwood formation in different plant species. Together, these probably represent Nature's most abundant reserves of organic substances on land.

Initially, his studies largely involved identification of numerous phenolic constituents, such as leucoanthocyanins, tannins, flavonoids, lignans, ellagitannins, stilbenes, C-glycosylflavonoids, and related substances from different woody plant species. Those phytochemical investigations began in the days before later developments led to the routine $^{1}H/^{13}C$ NMR spectroscopies that we now take for granted. He also identified the phenolic constituents in kino (eucalypt gum exudates) and in the deposits of heartshakes in heartwood, as well as studying those in *Pinus radiata* wood whose formation were induced. The latter can be formed as a result of the symbiotic relationship between the European wood wasp (*Sirex noctilio*) and the white rot fungus (*Amylostereum areolatum*). This insect pest (Fig. 1a) came to Australia from Europe/Northern Africa, and its symbiosis with the fungus can result in severe damage to pine stands in eastern Australia; female wasps introduce the fungus through injection into the wood (along with a toxin) during oviposition. Two tunnels are bored: one for the eggs and the other for the fungus (Fig. 1b).

His pioneering work also took him into many other different scientific realms. This included: identifying various chemotaxonomic relationships; establishing the chemical basis of various heartwood "extractives" which can function as growth inhibitors of wood-rotting fungi and other microorganisms, e.g. stilbenes, ellagitannins, and other metabolites, as well as podocarpic acid from heartshakes of *Dacrydium* species. He also began to explore the biosynthesis of many different wood "extractives" in different plant species. Upon reflection, the latter studies included important pioneering contributions to our understanding of various biosynthetic pathways, such as to the (hydroxy) stilbenes and flavonoids. Those studies began in the 1950s and helped set the path for the future molecular studies which continue to this day.

Other noteworthy features of his pioneering work also include: demonstration that neighboring cell types in heartwood tissues of western hemlock (Fig. 1c) can accumulate different lignan compositions (i.e. largely α-conidendrin in one, hydroxymatairesinol in another); such deposits can also often be found in crystalline form. Additionally, he showed that some woody plants contain other "extraneous constituents" in near pure inorganic form (e.g. Si, Al and Ca salts, depending upon the species). Interestingly, they can be specifically deposited in ray parenchyma, vessels, and fibrous elements of the particular wood species involved. He also noted a relationship between tension (reaction wood) formation to that of ethylene production, and emphasized early on the need to correlate (bio)chemical events with plant anatomy/morphology, cell, and tissue type.

doi:10.1016/j.phytochem.2008.11.003

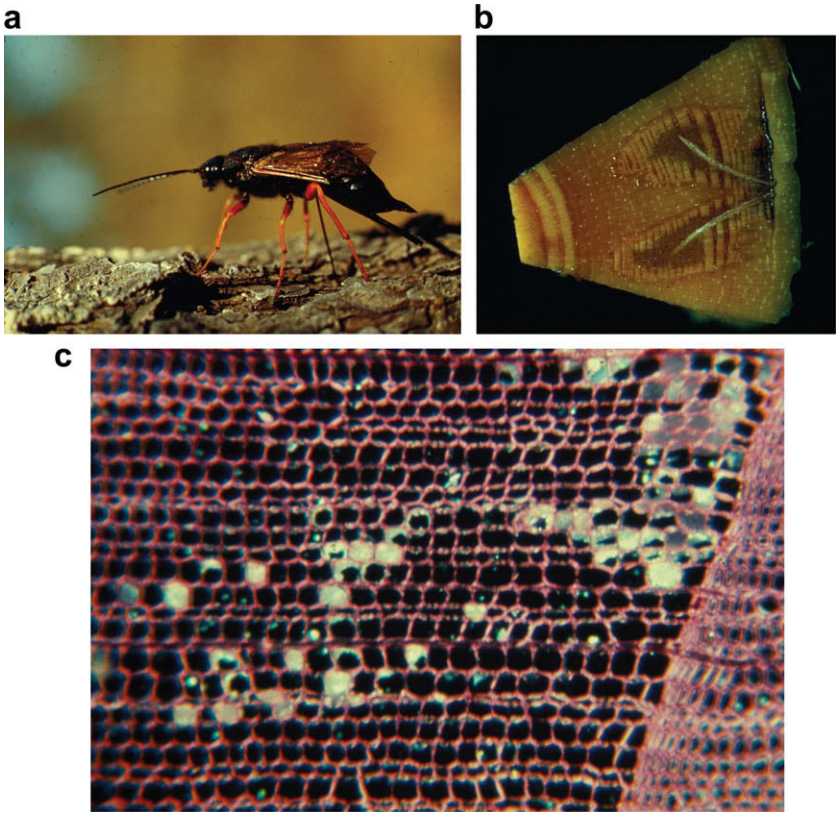

Fig. 1. *Sirex noctilio* (a) and bark of *Pinus radiata* (b). Note ovipositor *Sirex* tunnels, one for eggs, second for fungus; (c) milky and transparent deposits in adjacent tracheids of western hemlock due to hydroxymatairesinol and α-conidendrin (from W.E. Hillis in 1998).

Ted Hillis' work thus largely gave the needed (bio)chemical insights as to how distinct plant species engender very different properties to their woods (e.g. in terms of durability, pest and pathogen resistance, etc.). This, in turn, helped provide the basis and impetus for the subsequent molecular studies that we enjoy today in the study of wood/heartwood formation. Indeed, one such study is in the dirigent protein transcript expression in heartwood-forming tissue in this issue (see Patten et al.).

Ted was born on 9th February 1921 in Geelong, which is the second largest city in Victoria and located approximately 100 km west of Melbourne. After graduating from Geelong High School, he went to the Gordon Institute of Technology to study Industrial Chemistry and gained a Diploma in 1939. During World War II, he worked as a control chemist in the Coal Gas Industry. In 1942, he then joined the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization (CSIRO) as a Technical Officer. His first research work was on isolating mannitol from *Myoporum platycarpum* wood. He was later transferred to the Division of Forest Products, CSIRO in 1947. At the same time, he continued to study part time at the University of Melbourne, where he was also a Resident Tutor at Queen's College. Ted obtained his Bachelor of Science degree in 1947, followed by a Master of Science in 1951, and a Doctor of Science degree in 1966; all degrees were from the University of Melbourne.

In 1954–1956, Ted became an analyst of mangrove bark and an advisor to the Papua New Guinea Department of Forests: He also consulted for a private industry, which established a mangrove tannin extraction factory in West Papua and conducted the first factory trial to manufacture plywood using mangrove tannin adhesives in Sydney in 1957. This work extended the exploration of the chemical properties and applications of wattle and radiata tannins.

We also owe much of what we know about *Eucalyptus* species due to Ted Hillis' work, since these species are extremely difficult to distinguish using anatomical and biological characteristics alone. Thus, he identified the polyphenols from various *Eucalyptus* leaves, and this can now be used as an aid in classification. A series of five substantial publications entitled "Polyphenols in leaves of *Eucalyptus* species: a chemotaxonomic survey" were published in *Phytochemistry* in 1966–1967, and this work formed the core of his Doctor of Science thesis in chemistry and biochemistry from the University of Melbourne in 1966. During this period, he initiated and edited a book entitled "Wood extractives and their significance to the pulp and paper industries" in 1962. This publication became a classic textbook for both researchers and young students all over the world. Ted's research activities also attracted numerous scientists particularly from Japan, USA, Canada and Germany, to study with him. From that time on, his studies expanded enormously from chemistry and biochemistry of polyphenols to chemotaxonomy and wood anatomy, plant pathology, wood physics, wood seasoning, wood adhesion & technologies, and also tree breeding. Based on his achievements, he was promoted in 1972 to Chief Research Scientist, the highest research classification within CSIRO.

As mentioned above, Ted also had a unique opportunity in 1956 to work with E.C. Bate-Smith and Terry Swain at Cambridge University, which was fully supported by CSIRO. Scientific papers on chemistry and biochemistry of plant polyphenols quickly followed from this collaboration, most being published in Nature over the period from 1957 to 1959. This period was one of the most important stages in his scientific career.

Taken together, throughout his scientific career, he published over 200 scholarly papers and review articles, of which more than ten per cent were in *Phytochemistry*. However, he was also a frequent contributor to other journals, such as *Nature*, as well as to numerous chemical, biochemical and wood science related publications. Four books were also published, including "Heartwood

and Tree Exudates" in 1987 and "Eucalypts for Wood Production" (edited with A.G. Brown) in 1978, 1984, 1988 (Chinese translation 1990).

Ted additionally taught as Visiting Fellow at the Australian National University in Canberra (1974–1986), Visiting Professor at the University of British Columbia in Canada (1984) and established a Wood Science course at the University of Lae, Papua New Guinea (1975–1976). He was part time Lecturer at the University of Melbourne (1972–1974) and at the Australian Pulp and Paper Institute, Monash University (1990–1999).

Ted was Coordinator of the Forest Products Division (1976–1983) and Executive Board Member (1976–1983) of the International Union of Forest Research Organizations (IUFRO) and became an Honorary Member in 1986. He also served as Foundation Chairman for the Australian Branch of the Institute of Wood Science (1973–1977). He was an Honorary Member of the Chinese Society of Chemistry and Chemical Engineering of Forest Products since 1981 and an Honorary Member of the International Association of Wood Anatomists (IAWA) since 1981. He was elected as a Fellow (1970) and President (1978–1982) of the International Academy of Wood Science (IAWS) and Academy Lecturer (1985, 2006) and served as an Editorial Board Member of the Journal, "Wood Science and Technology" (1977–1999).

His outstanding contributions to the science and technology of woody plants, and their associated industries, were recognized domestically and internationally by numerous awards. He was elected as a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) (1980). He was also awarded the Stanley A. Clarke Memorial Medal from the Institute of Wood Science (1986), the Centenary Medal by the Australian Government (2003), and the Member of the Order of Australia (AM)(2003). The latter is one of the most prestigious awards made by the Australian Government to honor its exceptional citizens.

Ted never really retired from his research. Even shortly after the passing of his wife, Marjorie in July 2005, he attended the IUFRO World Congress in Brisbane in August 2005, and in the following year gave the Academy Lecture at the IAWS meeting in Melbourne in November 2006 entitled "Wood Science in the Future". This talk encouraged those present to look forward, as he pointed to where he believed science might go in the rapidly expanding fields of wood formation and utilization.

In the early 1950s, Ted lived in Gardenvale, 5 km south of Melbourne. He sang in the local Methodist Church Choir, where he met his future wife, Marjorie. They married at Queen's College, the University of Melbourne on 15th November 1952. During his entire career, he maintained an extremely high level of determination and dedication towards his research, which may have been formed by his experiences during the Great Depression in the 1930s. Furthermore, his scientific success owed much to the life-long support and total dedication of his wife. At the same time, they had established a wonderful family with three talented children. After his partial retirement at the age of 65, Ted travelled extensively with Marjorie and they immensely enjoyed cruising in Alaska and the South Pacific and the Great Barrier Reef in Australia. They also experienced travel in China, Canada, Germany, Sweden and many other countries.

Ted's spirit and passion for research in the fields of phytochemistry and wood science will have a lasting influence on our minds, and will be admired and respected by many friends, colleagues and students all over the world. He is survived by his children Rosemary, David and Margaret, his sons-in-law Charlie and Don, daughter-in-law Diane and his grandchildren James, Catherine, Melissa, Michael and Stephanie.

Ted, we proudly salute you for your remarkable scientific achievements and the enduring legacy that you have left the scientific community.

Rosemary Hillis
Norman G. Lewis
Yoshi Yazaki
Washington State University, Institute of Biological Chemistry, Clark Hall 467, Pullman, WA 99164-6340, United States.
Tel.: +1 509 335 2682; fax: +1 509 335 8206. (N.G. Lewis)
E-mail address: lewisn@wsu.edu (N.G. Lewis)