Tribute to Bjarni Jónsson

J. B. Nation

This *Algebra Universalis* Topical Collection is dedicated to the memory of Bjarni Jónsson, who died September 30, 2016 at the age of 96. He was a pioneer, guide, friend, and mentor to so many of us.

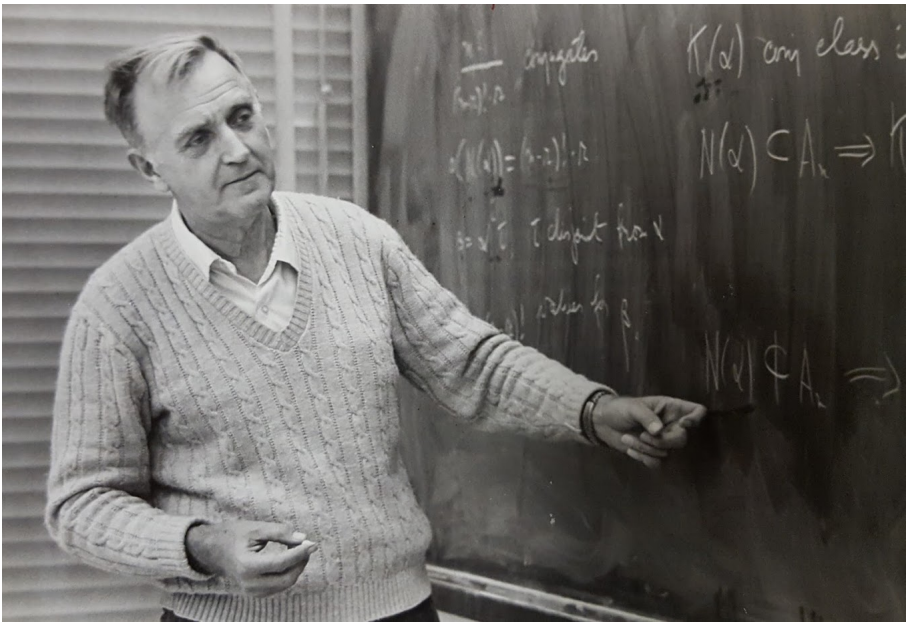

FIGURE 1. Bjarni Jónsson

1. Biography

Bjarni Jónsson was born on February 15, 1920 at Dragháls, Iceland. He was the third of the ten children of Jón Pétursson and Steinunn Bjarnadóttir,

nine of whom (5 boys and 4 girls) survived infancy. Dragháls was the farm of his father's family.

Bjarni was named for his maternal grandfather Bjarni Bjarnason. His grandfather bought the farm Geitaberg in Svínadalur around 1900. In Bjarni's memory, there was never a goat on the mountain nor a pig in the valley. The farm had a few milk cows and several hundred sheep. When he was about nine months old, Bjarni was sent to live with his grandparents at Geitaberg. He stayed there, with occasional visits to his family at Dragháls, until after his grandfather died in December 1928, when he moved back to Dragháls.

There was no school in rural Iceland. A traveling teacher would come and stay on one of the farms to give lessons. The kids who lived nearby would walk to the lessons; those a little farther away would stay on nearby farms. "By the age of 14 you were done with education." But Bjarni's grandfather, Bjarni Bjarnason, told his son, also named Bjarni Bjarnason and a medical doctor, to put Bjarni Jónsson on the education track. So around 1931 Bjarni moved in with his Uncle Bjarni, first in Akureyri and later Reykjavík. He attended high school at the Mentaskolinn in Reykjavík, graduating in the spring of 1939.

Before World War II, the best Icelandic students went to university in Europe. By 1939, this was no longer an option. So Bjarni got a job as a bookkeeper in an office in Akureyi. Since he was good at math, his uncle thought accounting was an ideal job for him. Bjarni disagreed, and started looking for ways to further his education. Meanwhile, Icelandic authorities arranged for a group of good students to study in the United States. Bjarni won one of these scholarships, and in the fall of 1941 sailed in a convoy to New York, and then took a cross-country bus to Berkeley.

With transfer credits from Mentaskolinn, he received his undergraduate degree in the spring of 1943. As an undergraduate, he took a course in matrix theory from Alfred Tarski. In Bjarni's words, "It was pretty routine stuff, but he snuck in some deeper material occasionally, and I saw that there was something there."

Bjarni continued studying with Tarski at Berkeley, and obtained his Ph.D. in 1946 with a dissertation on *Direct decompositions of finite algebraic systems*. His first academic job was at Brown University.

During this period at Brown, Bjarni married Amy Sprague. They had a son Eric (b. 1951) and daughter Meryl (b. 1953). Somewhat restless at Brown, Bjarni twice took leave to teach a semester at Berkeley, and spent the 1954–55 academic year at the University of Iceland. Upon returning from Iceland, he immediately went to a position at the University of Minnesota. (His second wife, Harriet Parkes, was also at UM at that time, but they did not meet.)

While at Minnesota, Bjarni and Herb Federer wrote a calculus book [24], which he aptly described as "an artistic success – and a box-office failure."

In 1966, Bjarni went to Vanderbilt University. Tradition has it that his employment package included season tickets for basketball. This must have

been true, because Bjarni seldom missed a Vanderbilt basketball game. He also enjoyed watching baseball, both Vanderbilt baseball and the Minnesota Twins.

The Vanderbilt era brought important changes to Bjarni's life. He was divorced from his first wife. In 1970 he married Harriet Parkes, a Nashville native, and their daughter Kris was born in 1971.

He took up running as a sport, and did well in his age group competing in races in Percy Warner Park. Later in life he still enjoyed long walks.

In 1966 Bjarni bought a cabin on Horseshoe Lake near Backus, Minnesota. It is the most peaceful place on earth, near the end of a mile-long gravel dirt road, yet only three miles from a bustling town of well over 100 people. For most of the rest of his life, he spent every summer there. The author visited often. Other mathematicians, including Alan Day, Bill Lampe, Mai Gehrke and Peter Jipsen enjoyed Bjarni and Harriet's hospitality at the cabin. A converted woodshed served as an office where he could work, and it was understood that mathematics had a certain priority. Then he would disappear for a ten-mile run around nearby Pine Lake.

The author also went to Vanderbilt in 1966, as an undergraduate student. Bjarni became my undergraduate advisor, and I wound up taking a couple of years of algebra from him. Some of the lectures were transforming, and I can even remember which room of Old Science Hall they were in. I particularly remember one on the isomorphism theorems, and another on equational classes. Bjarni's lectures went to the heart of the matter.

But the most important thing he did was simpler. He gave me Tom Whaley's dissertation and said, "Here, read this." I had never seen such mathematics before, and was soon hooked.

Bjarni organized an incredible seminar for the fall semester of 1969. Bernhard and Hanna Neumann, their son Peter and student Mike Vaughan-Lee all spent the semester at Vanderbilt. I took field theory from Peter and complex variables from Mike, while Bernhard and Hanna Neumann lectured at the weekly seminar. All of them gave me kind encouragement.

Bjarni retired from teaching in 1993, and in 2005 they moved from Nashville to Cincinnati, where Kris and her family live. As often happens with older folk, Bjarni turned to the thoughts of his youth – in this case, canonical extensions and the foundations of number systems.

Harriet died on December 19, 2014. Bjarni passed away peacefully on September 30, 2016, surrounded by his children.

We will remember his enthusiasm for mathematics, integrity, and devotion to students and colleagues. He was a kind and gentle man. And I will especially miss the dry wit, so characteristically Icelandic, that enlivened us in his presence.

2. Mathematics

The Jónsson Symposium was held from July 2 to July 6, 1990 in Laugarvatn, Iceland to celebrate Bjarni's 70th birthday. The proceedings of the symposium were published as volumes 31 and 32 of *Algebra Universalis* in 1994. Volume 31 contains surveys of Bjarni's contributions to universal algebra by Kirby Baker [95], and to lattice theory by J. B. Nation [100], with a forward by George McNulty [99]. Bjarni continued to be active after his 70th birthday, and Mai Gehrke has written a review of their joint work on canonical extensions [96]. So this article will only briefly survey Bjarni's mathematics, and refer the reader to those articles for a more comprehensive report.

Bjarni's earliest work was on the uniqueness of direct product decompositions of finite algebras. It was a theme to which he returned often. Chapter 5 of McKenzie, McNulty and Taylor [98] provides a good introduction to this topic. A sample theorem, from [34], is that *Every finite algebra with modular congruence lattice and a one-element subuniverse is uniquely factorable.* Other papers of Bjarni on this topic include [1, 2, 10, 12, 13, 17, 30, 31, 32, 38, 64].

Another important early paper was Bjarni's proof in [7] of Whitman's theorem that *Every lattice can be represented as a lattice of equivalence relations.* Bjarni claimed that he devised his proof because it was easier than reading Whitman's paper [107]. It is good that he did, because besides introducing a now-standard construction method, it focused his attention on Arguesian lattices through permuting equivalence relations.

In 1945, Schützenberger found a lattice equation that holds in the lattice of subspaces of a projective geometry if and only if Desargues' Law holds in the geometry [104]. Bjarni found a simpler equation with the same property, now known as the *Arguesian law*, and applied it in a number of settings. The classic version for complemented modular lattices is from [8]:

For a complemented modular lattice, the following conditions are equivalent.

(1) $\mathbf{L}$ *is Arguesian.*
(2) $\mathbf{L}$ *has a representation by permuting equivalence relations.*
(3) $\mathbf{L}$ *has can be embedded into the normal subgroup lattice of a group.*
(4) $\mathbf{L}$ *has can be embedded into the subgroup lattice of an abelian group.*
(5) $\mathbf{L}$ *has can be embedded into a direct product of subspace lattices of vector spaces.*

Bjarni extended von Neumann's coordinatization theorem in the following way [18]: *If* $\mathbf{L}$ *is a complemented Arguesian lattice with a spannning* n*-frame* ($n \geq 3$)*, then there is a regular ring* $\mathcal{R}$ *such that* $\mathbf{L}$ *is isomorphic to the lattice of all finitely generated submodules of* ${}_{\mathcal{R}}\mathcal{R}^n$. A variation coordinatizing primary Arguesian lattices with a spanning n-frame ($n \geq 3$) is due to Jónsson and George Monk [40]. Related papers are [15, 20, 26, 44, 71, 74].

A series of papers with Alan Day characterized failures of the Arguesian law in a modular lattice [70, 72, 75, 79, 85]. Bjarni and Ralph Freese proved

the remarkable result that for varieties, *Congruence modularity implies congruence Arguesian* [52].

Bjarni's landmark paper [35] includes both a Mal'cev condition for congruence distributivity, and Jónsson's Lemma: *The subdirectly irreducible members of the variety generated by a collection X of algebras in a congruence distributive variety are contained in* $\mathbb{HSP}_u(X)$. The roots of Jónsson's Lemma can be found in Alden Pixley's work on primal algebras [101]. Of course, lattices are congruence distributive. Bjarni and Ivan Rival showed that the variety generated by the pentagon $\mathbf{N}_5$ has exactly 16 covers in the lattice of lattice varieties [59]. Other applications to lattice varieties include [36, 46, 49, 56, 57, 63].

Bjarni had a continuing interest in free algebras and free products of all sorts. His paper with James Kiefer [28] identified the join and meet semidistributivity laws, and connected them with canonical forms. Related papers along these lines are [2, 21, 22, 23, 27, 41, 43, 48, 77, 82].

Assuming the generalized continuum hypothesis, Bjarni proved the existence of universal relational systems for classes satisfying certain conditions [11, 19, 29, 33, 69]. The amalgamation property and pure embeddings played a role in this work.

With Dwight Duffus, Ivan Rival and Ralph McKenzie, Bjarni investigated the arithmetic of ordered sets: factorization and cancellation under the operations $\mathbf{P} + \mathbf{Q}$, $\mathbf{P} \times \mathbf{Q}$ and $\mathbf{P}^{\mathbf{Q}}$, in the papers [58, 64, 65, 66].

The longest path through Bjarni's research starts at Boolean algebras with operators, goes to relation algebras, and comes back to distributive lattices. In [5], Jónsson and Tarski prove that *Every Boolean algebra with operators (BAO)* $\mathbf{B}$ *has a canonical extension, i.e., an embedding into a complete and atomic BAO* $\mathbf{B}^\sigma$ *such that* $\mathbf{B}$ *is compact in the Stone topology on* $\mathbf{B}^\sigma$*, and* $\bigvee\bigwedge \mathbf{B} = \mathbf{B}^\sigma = \bigwedge\bigvee \mathbf{B}$. Mai Gehrke and Bjarni extended this to bounded distributive lattices with operators (DLO): *Every DLO* $\mathbf{L}$ *has a canonical extension, i.e., an embedding into a doubly algebraic DLO* $\mathbf{L}^\sigma$ *such that* $\mathbf{L}$ *is compact in the Priestley topology on* $\mathbf{L}^\sigma$*, and* $\bigvee\bigwedge \mathbf{L} = \mathbf{L}^\sigma = \bigwedge\bigvee \mathbf{L}$*;* see [86, 87, 90, 91, 92]. These results are explained in [84, 96, 97].

Between BAOs and DLOs, Bjarni worked on the axiomatization and representability of relation algebras [67, 68, 76, 77, 78], and residuated lattices [83, 88, 93].

The shortest path through Bjarni's research involves Jónsson algebras and Jónsson cardinals. Apparently, in 1962 Bjarni asked: *For which infinite cardinals κ can one find an algebra* $\mathbf{A}$ *of finite type with* $|\mathbf{A}| = \kappa$*, but* $|\mathbf{B}| < \kappa$ *for every proper subalgebra* $\mathbf{B} < \mathbf{A}$*?* But Bjarni wrote no papers on Jónsson algebras, though his student Tom Whaley wrote a couple [105, 106], and Saharon Shelah wrote several papers showing the existence of various types of Jónsson algebras, summarized in [102, 103].

Bjarni only occasionally spoke of his love of mathematics, but when he did, you could see the light in his eyes. It is reflected in the breadth and depth of his work.

FIGURE 2. Bjarni Jónsson, 2016 (photo by John Nation)

3. Honors

Bjarni served on the editorial board of several mathematics journals, including the *Houston Journal of Mathematics*, *Algebra Universalis* and *Order*. In 1974 he was an invited speaker at the International Congress of Mathematicians in Vancouver. He received Vanderbilt's Harvie Branscomb Distinguished Professor Award in 1974, and the Earl Sutherland Prize for Achievement in Research in 1982. He was awarded an Honorary Doctorate by the University of Iceland in 1986, and received the Knight's Cross from the president of Iceland in 1991. In 2012 he was elected an inaugural fellow of the American Mathematical Society.

4. Quotes

"Mathematics is primarily an activity, and secondarily a body of knowledge."

"Adventure is not in the guidebook and beauty is not on the map. The best one can hope for is to be able to persuade some people to do some traveling on their own."

5. Ph.D. Students

(1) Allen Clarke, Brown, 1951.
(2) Daniel Wagner, Brown, 1951.
(3) Edgar Smith, Jr., Brown, 1955.
(4) Peter Fillmore, Minnesota, 1962.

(5) Steven Monk, Minnesota, 1966.
(6) Fred Galvin, Minnesota, 1967.
(7) Tom Whaley, Vanderbilt, 1968.
(8) Dang X. Hong, Vanderbilt, 1970.
(9) Robert Appleson, Vanderbilt, 1975.
(10) Henry Rose, Vanderbilt, 1980.
(11) Jeh Gwon Lee, Vanderbilt, 1983.
(12) Young Kang, Vanderbilt, 1987.
(13) Peter Jipsen, Vanderbilt, 1992.
(14) John Rafter, Vanderbilt, 1997.

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