

Frederick Benington

C Raymond Perrault

July 27, 2020

Revised December 22, 2024

Frederick Benington (1916-1997) was, to the best of my knowledge, the first scientist descendant from Arthur Benington. He had a distinguished career in industry and academia as a chemist who studied combustion and hallucinogens, with a significant sideline as a speleologist.

Early days

Fred Benington was born on December 12, 1916 in Chelsea, Massachusetts, the eldest child of William Frederick Benington and Marjorie Beatrice Taylor¹. His father, the eldest son of Arthur



From The Manet, North Quincy HS, June 1932

Benington and Elizabeth Davidson, was, like all his siblings, born in Montreal, and became an electrical engineer. He died in 1928 in Hopewell, Virginia, leaving the 12-year old Fred and his 11-year old sister Marjorie in the hands of their mother, the daughter of Thomas Taylor, a carpenter, and Annie Ferguson, immigrants to Massachusetts from Nova Scotia. Fred graduated from North Quincy High School, in Quincy, Massachusetts, where he was on the student council².

Fred graduated from Tufts University in Boston in 1939 with a BA in Maths and Chemistry, having submitted a thesis titled *The addition of ammonia bases to some*

*new alpha-beta unsaturated nitro compounds*³. The year of his graduation, he was living in Niagara Falls with his mother and sister and was working as a chemist for Innis Spieden, a

¹ All biographic information is drawn from ancestry.com.

² The Manet, North Quincy High School, 1932. This appears to be from Fred's junior year.

³ Tufts University Archives. Fred entered Tufts in 1935, and graduated the same year as his sister Marjorie. Photos of both are in the [1939 Tufts Yearbook](#). He may have worked for a couple of years between high school and college.

chemical manufacturer⁴. His first scientific articles, in organic chemistry, jointly with [David E Worrell](#), a professor at Tufts, appeared in 1938 and 1940 [1, 2]⁵,

On September 7, 1940, Fred married, in Syracuse NY, Bernice Angeline Brown, born on July 29 1915 in Boston, daughter of Jay D Brown (1872-1963), a commercial traveler, and Genevieve Rice (1881-1932). A month later, he registered for the draft in Niagara Falls, New York. In 1942, he was working for Niacet, another chemical manufacturer in Niagara Falls.

Fred and Bernice had a daughter, Phyllis, who was born on September 27, 1943, at an unknown location, and a son, Michael, born November 2, 1945 in Corning, New York, indicating that Fred spent part of the war in Corning, working for Corning Glass⁶. Although he registered for the draft, there is no evidence that he served in the military. Corning was involved in a number of [projects](#) for the war effort, including the creation of glass kitchenware that was used by the troops, and glass products whose purpose was to reduce the need for metal.

Combustion

Fred joined [Battelle Memorial Institute](#) in Columbus, Ohio, around 1947⁷. Founded in 1929, Battelle is a non-profit R&D organization whose initial focus was on materials and material science. His first publication there is on a method for analysing combustion products of jet fuels [3]. His second is on the recovery of uranium from shale [4].

Fred is one of 11 authors, all from Battelle, of a 791-page monograph titled *Injection and Combustion of Liquid Fuels* [19]. The monograph is not original research, but rather “contains a review of material in the unclassified literature relating directly to the fundamental physical phenomena involved in steady flow processes in high-intensity combustors”. Fred is the sole author of 4 of 19 chapters and co-author on a fifth. His chapters focus on the evaporation of droplets of fuels, examining their kinetics and thermodynamics, the evaporation of a single static droplet, then that of a droplet in motion, then of aerosols of many droplets. Each of the chapters, from 20 to 60 pages long, could be the background chapter of an MS or PhD thesis. They discuss the theoretical background, its agreement with known experimental work, and identify questions deserving further research. Although the report was published in March 1957, the funding from the Aeronautical Research Lab at Wright-Patterson Air Force Base started in 1950.

Between 1952 and 1955, Fred, with R. H. Poirier, published a series of four articles on the chemistry of Hydrazyl-free radicals, which are involved in the combustion of hydrogen and

⁴ 1939 census, Ancestry.com

⁵ Numbers in brackets refer to publications in the list in the Appendix.

⁶ Fred Benington obit, The Birmingham News and the Birmingham Post-Herald, 24 April 1997.

⁷ Fred's obit says he had been at Battelle 16 years when he joined the University of Alabama in 1963.

hydrocarbons with oxygen used as an oxidant [8, 9, 11, 12]. This work was supported by the US Air Force.

Hallucinogens

In March 1951, Fred published the first of over 70 articles on the synthesis of hallucinogens and the measurement of their physiological properties. Co-authored with Richard D. Morin, who was to be a life-long collaborator, the paper titled *An Improved Synthesis of Mescaline*, described a synthesis route that improved the efficiency of previous methods from 21% to 65% [6]. It is mentioned in the Wikipedia article on [mescaline](#). This was followed by a series of nine articles between 1954 and 1958 with Morin and Leland C. Clark on the synthesis of mescaline analogs [10, 14, 15, 16, 18, 21, 23, 24]. An article on the effects of psychotomimetic drugs on certain enzymes in the mammalian brain appeared in 1963 the *Journal of Nervous and Mental Diseases*, Fred, Morin and Clark's first article outside the chemistry literature [17].

In 1958, Clark accepted a position as Associate Professor of Biochemistry in the Department of Surgery at the University of Alabama Medical Center in Huntsville, Alabama. Fred and Morin followed him in 1963. John R. Smythies joined the group about 1967 and the following year, Smythies, Clark, Morin and Fred published the first of four articles in *Nature* on the effects of amphetamines and related substances on animals [36, 44, 47, 49]. Clark left the group in 1968 to focus on his work on biosensors.

Richard Dudley Morin (1918-2001) was born in Illinois and received a BS in 1942 and a PhD in Chemistry on the synthesis of hormones, in 1944, both from the University of Michigan. He held positions as a research chemist at Battelle and as Professor of Medicinal Chemistry at the University of Alabama Medical Center and almost all his publications are co-authored with Fred⁸.

Leland C. Clark, Jr. (1918-2005) was born in Rochester, NY and received a BS in Chemistry from Antioch College in 1941 and a PhD in Biochemistry and Physiology from the University of Rochester in 1944. His first position was as Assistant Professor of Biochemistry at Antioch, where he did much of his work on hallucinogens jointly with Fred and Morin, until he joined the University of Alabama in 1958. In 1962 he co-invented the first biosensor, and moved to the Cincinnati Children's Hospital Research Foundation in 1968. His work on biosensors, in particular for glucose and oxygen monitoring, won him wide acclaim and he was elected to the National Academy of Engineering in 1995⁹.

⁸ Ancestry.com; University of Michigan Library Catalog

⁹ Leland Clark, https://en.wikipedia.org/wiki/Leland_Clark

John Raymond Smythies (1922-2019) was a British neuroscientist. Born in India and trained in medicine at Cambridge, he made contributions to the neurochemistry of schizophrenia, the neuropharmacology of psychedelic drugs, and the neuroanatomy of synapses. Before his appointment as the C. B. Ireland Professor of Psychiatric Research at University of Alabama, he held positions at the University of Edinburgh and University of California at San Diego. Smythies's Wikipedia article says that at the start of his book on the effects of mescaline, *The Doors of Perception*, published in 1954, Aldous Huxley credits Smythies for having inspired him to take the substance¹⁰. The story appears to be a bit more complicated. Huxley does cite papers by Smythies and his collaborator, Humphry Osmond, but it appears that it was Osmond who traveled from Saskatchewan, where he and Smythies were working, to Los Angeles in May 1953 to administer the mescaline Huxley had requested¹¹.

As well as doing research on hallucinogenic amphetamines, Fred taught psychiatric residents, but also graduate courses in chemical kinetics, thermodynamics, and the chemistry of natural products¹².

The reader may ask whether, given the availability of all these drugs, Fred might have been enticed to partake. One of his graduate students who came to Alabama in the early 70s after experiencing the 60s in Berkeley, confirmed that Fred and Morin had tried many of the drugs they were working on and encouraged others to do so safely. Different drugs produced different color experiences, which no animal models could reveal¹³.



Fred Benington (NSS News, 1962)

Spelunking

Although the study of amphetamines was the center of Fred's academic career, he had a significant sideline in the application of chemistry to problems arising from the exploration of caves. He was associated with the [National Speleological Society](#) (NSS) and participated in the exploration of the large system of Mammoth and Salts Caves, part of [Mammoth Caves National Park](#) in Kentucky, at 400 miles, the largest known cave system on earth.

In an article published in *Science*, he identified a new mineral appearing in stalactites, sodium hemicalcium sulfate dihydrate,

¹⁰ John Raymond Smythies, https://en.wikipedia.org/wiki/John_Raymond_Smythies

¹¹ Humphry Osmond, https://en.wikipedia.org/wiki/Humphry_Osmond; Aldous Huxley (1954), *The Doors of Perception*, p. 2, footnote 1.

¹² Fred Benington obit.

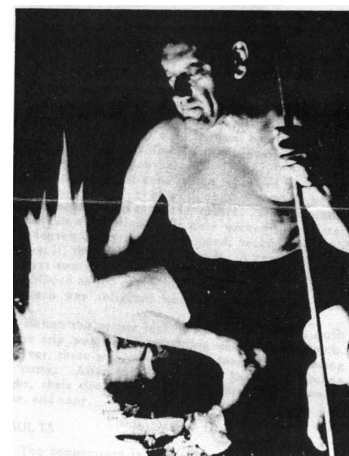
¹³ Toni B Klein, personal communication, 2020.

which is unstable at temperatures above 25°C [28]. The first specimens effloresced when taken out of the caves, and it was only once they were put on ice before removal that they could be taken to the lab for analysis. The mineral has since been found in nature several times and named *eugstrite*¹⁴. This work was done under the auspices of the [Cave Research Foundation](#), the research arm of the NSS, of which Fred was a founder and one-time director¹⁵.

Two years later, he collected samples of soot from the roof of a recently discovered part of Salts Cave which he showed by carbon dating to be from 3075 +/- 140 years before the present (1960), pushing back the known presence of humans in the caves by about 800 years [35]. Fred participated in an expedition to Salts Cave to test various forms of cane torches that might have been used by cave dwellers for illumination¹⁶.

Fred was Executive Vice-President of the NSS in 1962 and elected Fellow of the NSS in 1968.¹⁷ Spelunking seems to have been a Benington family activity, as exploration of caves in Ohio, Kentucky and Jamaica is mentioned in the obit of his son Michael¹⁸.

Fred's obit mentions that he was a member of the Explorer's Club.



Fred testing torches at Salts Cave, 1964

Chasing eclipses

Starting early in the 20th Century, expeditions were mounted to chase solar eclipses from the air, to take pictures unimpeded by clouds, and to prolong the time available for exposure. Expeditions were sponsored by US, UK and Canadian military and civilian organizations. Fred was a civilian member of the 1954 USAF [Solar Eclipse Expedition](#) to Northern Labrador, where he acted as camera operator, repairman, and weather officer¹⁹. The path of the eclipse on June 30, 1954 went over Wisconsin, Ontario, Hudson's Bay, Labrador, then over the Atlantic to the Hebrides, and over northern Europe. The aircraft was an RAF [Avro Lincoln](#) modified so that photographs could be taken through an open door while flying at 30,000 feet²⁰. The results of

¹⁴ William B. White (2017), Mineralogy of Mammoth Cave, in *Mammoth Cave: A Human and Natural History*, (Hobbs, Olson, Winkler, Culver, eds.), Springer.

¹⁵ Notice in NSS News, September 1962.

¹⁶ Michael F. Ehman (1965) Cave Torches as Cave Illumination, NSS News, 24, 34-36.

¹⁷ NSS News, *ibid.*; [Fellows of the National Speleological Society](#),

¹⁸ Michael Benington [obituary](#) (2013), The Birmingham News.

¹⁹ NSS News, *ibid.*

²⁰ The Avro Lincoln was capable of flying up to 43,000 feet. Blackwell writes "Physiological difficulties made it inadvisable to attempt observations from this height, and a height of 30,000 ft was chosen to give the best compromise between sky darkening on the one hand, and aircraft stability and observer alertness on the other hand."

the expedition were reported in a paper authored by Donald Blackwell, then the Assistant Director of the Solar Physics Observatory at Cambridge University.

Blackwell, 1954, MNRAS, 115, 629.

TSE: 30 June 1954

Eclipse Observations: Lat = 61° 23.9'N, 1° 34.6'W



404 mm EFL Multi-Lens Occulting/Baffled Camera

8 images on one 12"-sq. Ilford HP3 plate.

4 for direct intensity measurements:

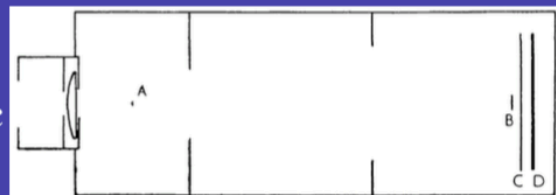
f/9 (14° x 28° FOV), f/20, f/49, f/130

4 for polarization: 2-f/9, 2-f/20

quad pol. 2 cm in front of film

parallel & perpendicular to ecliptic

**Exposure time: 1 min., start CII + 30s
for darkest sky**



ONE OF EIGHT

Guiding Error: 10' over 1m exposure.

The Avro Lincoln from the 1954 Solar Eclipse Expedition. From the slides for a presentation by Glenn Schneider (2007) *Up, Up and Away - Chasing the Umbra Into the Stratosphere (and Beyond)*.

Blackwell's article does not mention Fred, but he appears as a civilian passenger on manifests of flights out of and back to Westover Air Reserve Base in Chicopee, MA, leaving on June 8, 1954 for Goose Bay, Labrador, and returning on July 4²¹. It is not clear whether Fred was actually on the Avro. Blackwell writes: "We also acknowledge with gratitude the active cooperation of the Air Ministry who not only provided the special Lincoln aircraft but also made arrangements for testing the two Cambridge observers in a decompression chamber."²² There may have been US observers as well.

²¹ Ancestry.com

²² D.E. Blackwell (1955) A Study of the outer corona from a high altitude aircraft at the eclipse of 1954 June 30, Minutes of the Royal Astronomical Society, 115, 629-649.

Fred's obit also indicates that he was part of an expedition to observe the June 25, 1955 total solar eclipse in Vietnam²³. This was the first eclipse to be chased by a jet, in this case a USAF T-33 trainer, at 600mph. I have found little about the scientific results of the expedition or Fred's contribution to it. Fred did make a trip to South-East Asia in November 1955 on a government flight, but this was too late to have been part of the eclipse expedition.

Although eclipse chasing isn't strongly related to any of Fred's other known scientific pursuits, it is certainly consistent with his interest in photography and exploration. As to how he might have got involved in these in the first place, both expeditions took place while Fred was at Battelle, when much of his work was sponsored by the Air Force.

Family

Fred's last paper appeared in 1984 [89], when he was 68. It concerns a new drug for leukemia, for which a patent was granted in 1986 [90]. He died in Birmingham on April 21, 1997, at the age of 80.

Bernice, his first wife, died in California in 2000. Joyce Pelham, his second wife, died in Birmingham in 2021.

His son, Michael, became a builder in Birmingham and died in 2006. He married Penny Greene, a teacher, and has living children.

His daughter Phyllis married, divorced, and lives in Birmingham. I have not found any children.

Some Loose Ends

Most of this article was seeded by information in the NSS notice of his election to Executive Vice-President in 1962 and his obit, from 1997. A few activities are mentioned in these documents that I have not been able to find more details on.

Did Fred get a PhD?

Several of Fred's publications explicitly mention the honorific "Ph.D". His obit does not claim he got a Ph.D., but says that "his graduate work took place at Harvard, where he studied with Robert Burns Woodward. A boyhood friend, Woodward went on to win the Nobel Prize in chemistry for his synthesis of quinine". Woodward graduated from Quincy High School, in 1933, one year before Fred, then went to MIT where he received a BS in 1936 and a PhD in 1937 at

²³ https://en.wikipedia.org/wiki/Solar_eclipse_of_June_20,_1955

the age of 20²⁴. By the Fall of 1937 he was at Harvard where he was elected Junior Fellow in 1938 and started taking students in 1944. We know that Fred graduated from Tufts in 1939, and was employed in Niagara Falls and Corning NY from 1940 to at least 1945 and joined Battelle about 1947, so that there was time for him to get a Ph.D. between the end of the War and his joining Battelle, as witnessed not only by Woodward's blazing through MIT, but also by Richard Morin's getting a Ph.D. in 2 years at Michigan. However, the Harvard Registrar's office has no record of Fred getting any degree from Harvard, and there is no copy of a dissertation in the Harvard Library, whereas there is one of Morin's at Michigan. Woodward's obit (which I strongly recommend) is explicit about his having had a large number of collaborators, but no joint publication with Fred has been found. The obit is also clear about how not everything Woodward worked on got published, and that some unpublished work is still in his archive at Harvard. Library catalogs at Cornell, Rochester, Syracuse, and SUNY Binghamton, all close to Corning, and at Tufts, have been searched for a dissertation, with no success. [Proquest](#), which archives and distributes dissertations, has nothing either.

It should also be noted that Fred turned quite quickly to research on the synthesis of mescaline, a natural organic substance, directly in line with the research that was to make Woodward famous. It is quite likely that they worked together, even if this work never led to a degree²⁵.

Mountaineering

Both his obit and the NSS notice mention Fred's interest in mountain climbing, with the obit saying "He and a fellow member of the Chicago Mountaineering Club are credited with making the first ascent of the east face of Longs Peak in the Rockies." There is quite a bit of detail on Wikipedia on the climbing of [Longs Peak](#), especially its east face, called The Diamond, which was first climbed in 1960, but with no mention of Fred. Archivists of the Chicago Mountaineering Club could not confirm either that he had been a member, or participated in notable ascents with them.

²⁴Todd, L.; Cornforth, J.; T., (1981). "Robert Burns Woodward. 10 April 1917-8 July 1979". *Biographical Memoirs of Fellows of the Royal Society*. **27**: 628–695. [doi:10.1098/rsbm.1981.0025](https://doi.org/10.1098/rsbm.1981.0025)

²⁵ Academics without PhDs were common in Fred's time. For example, of the 68 tenure stream faculty listed in Tufts's yearbook from the year Fred graduated, 42 had no doctorates. Though less common now, academics without PhDs still exist, such as Freeman Dyson (1923-2020, Physicist, Princeton, Fellow of the Royal Society), Lynn Conway (1938-2024, Computer Science, U. of Michigan, National Academy of Engineering), Bob Floyd (1936-2001, Computer Science, Stanford, Turing Award winner), and Saul Kripke (1940-2022, Philosophy, Fellow of American Academy of Arts and Sciences).

Appendix: Fred Benington's Publications

1. Worrall, D. E.; Benington, F. (1938) Action of p-toluidine and p-phenylenediamine on substituted nitrostyrenes, *Journal of the American Chemical Society*, 60, 2844-2845; DOI: 10.1021/ja01279a005
2. Worrall, D., & Benington, F. (1940). The Action of Aromatic Amines on 3-Nitro-6-iodonitrostyrene. *Journal of the American Chemical Society*, 62(3), 493-494.
3. Benington, F. (1948). The capture of gas-phase free radicals with organic free-radical reagents. *Symposium on Combustion and Flame, and Explosion Phenomena*, 3(1), 448-452.
4. Recovery of Fuel Values from Oil Shales, 1949, Battelle Memorial Institute.
5. Arthur E Bearse, R A Ewing, John F Foster, G A Lutz, Paul D Miller, Hammett P Munger, F Benington, J V Parker. Progress Report for Dec 1949, Battelle Memorial Institute..
6. Benington, Fred; Morin, Richard (1951). "An Improved Synthesis of Mescaline". *Journal of the American Chemical Society*. 73 (3): 1353. doi:10.1021/ja01147a505.
7. Poirier, R. H., & Benington, F. (1952). Reduction of N-Nitrosodiphenylamine to unsym-Diphenylhydrazine by Lithium Aluminum Hydride¹. *Journal of the American Chemical Society*, 74(12), 3192–3192.
8. Poirier, R. H., Kahler, E. J., & Benington, F. (1952). The Chemistry of Hydrazyl free Radicals. I. Spectrophotometric Evidence on the Structure of α,α -Diphenyl- β -Picrylhydrazyl and α,α -Diphenyl- β -Picryl- β -Oxyhydrazyl. *Journal of Organic Chemistry*, 17(11), 1437–1445.
9. Benington, F., Shoop, E. V., & Poirier, R. H. (1953). The Chemistry of Hydrazyl free Radicals. II. Synthesis and Dissociation of Tetra(4-Fluorophenyl)Hydrazine. *Journal of Organic Chemistry*, 18(11), 1506–1510.
10. Benington, F., Morin, R. D., & Clark, L. C. (1954). MESCALINE ANALOGS. I. 2,4,6-TRIALKOXY- β -PHENETHYLAMINES. *Journal of Organic Chemistry*, 19(1), 11–16.
11. Poirier, R. H., & Benington, F. (1954). THE CHEMISTRY OF HYDRAZYL FREE RADICALS. III. FURTHER EVIDENCE OF THE CONTRIBUTION OF α -GROUPS TOWARD THE STABILIZATION OF α,α -DISUBSTITUTED- β -PICRYLHYDRAZYL FREE RADICALS¹. *Journal of Organic Chemistry*, 19(7), 1157–1162.
12. Poirier, R. H., & Benington, F. (1954). THE CHEMISTRY OF HYDRAZYL FREE RADICALS. IV. CHROMATOGRAPHIC STUDIES WITH α,α -DIPHENYL- β -PICRYL HYDRAZYL AND SOME OF ITS β -DERIVATIVES¹. *Journal of Organic Chemistry*, 19(11), 1847–1854.
13. Benington, F., Morin, R. D., & Clarke, L. C. (1954). Synthesis of 4-Hydroxy- and 4-Ethoxy-3,5-dimethoxy- β -phenethylamines¹. *Journal of the American Chemical Society*, 76(21), 5555–5556.
14. Benington, F., Morin, R. D., & Clark, L. C. (1955). MESCALINE ANALOGS. II. TETRA- AND PENTA-METHOXY-PHENETHYLAMINES. *Journal of Organic Chemistry*, 20(1), 102–108.
15. Benington, F., Morin, R. D., & Clark, L. C. (1955). MESCALINE ANALOGS. III. 2,4,6-TRIALKYL- AND 3,4-DIHYDROXY-5-METHOXY-PHENETHYLAMINES. *Journal of Organic Chemistry*, 20(9), 1292–1296.
16. Benington, F., Morin, R. D., & Clark, L. C. (1955). MESCALINE ANALOGS. IV. SUBSTITUTED 4,5,6-TRIMETHOXYINDOLES. *Journal of Organic Chemistry*, 20(10), 1454–1457.

17. Clark, L.C., Fox, R.P., Morin, R.D., & Benington, F. (1956). Effects of psychotomimetic compounds on certain oxidative and hydrolytic enzymes in mammalian brain. *The Journal of nervous and mental disease*, 124 5, 466-72 .
18. Benington, F., Morin, R. C., & Clark, L. C. (1956). Notes - Mescaline Analogs. VI. Mescaline Homologs. *Journal of Organic Chemistry*, 21(12), 1545–1546.
19. PUTNAM, A A ; BENINGTON, F, Einbinder, H, Hazard, HR, Kettelle, JD Jr, Levy, A, Miesse, CC, Pilcher, JM, Thomas, RE, Weller, AE, Landry, BA (1957) INJECTION AND COMBUSTION OF LIQUID FUELS, [DTIC](#) [funded by Aeronautical Research Lab, Wright Air Development Center, Wright-Patterson AFB, OH. Project initiated in 1950]
20. Benington, F., Morin, R., & Clark, L. (1957). Notes - New Synthesis of [Trichohocereine](#). *Journal of Organic Chemistry*, 22(2), 227–228.
21. Benington, F., Morin, R., & Clark, L. (1957). Notes - Mescaline Analogs. VII. 3,4,5-Trimethyl- β -phenethylamine. *Journal of Organic Chemistry*, 22(3), 332–333.
22. Morin, R., Benington, F., & Clark, L. (1957). Notes - Synthesis of 5,6,7-Trimethoxyindole Possible Intermediary Metabolite of Mescaline. *Journal of Organic Chemistry*, 22(3), 331–332.
23. Benington, F., Morin, R. D., & Clark, L. C. (1958). Mescaline Analogs. VIII. Substituted 5-Methoxy-and 5,6,7-Trimethoxyindoles. *Journal of Organic Chemistry*, 23(1), 19–23.
24. Benington, F., Morin, R., & Clark, L. (1958). Notes - Mescaline Analogs. IX. Tetra- and Pentamethyl- β -phenethylamines. *Journal of Organic Chemistry*, 23(12), 2034–2035.
25. Benington, F., Morin, R. D., & Clark, L. C. (1958). Synthesis of O- and N-Methylated Derivatives of 5-Hydroxytryptamine. *Journal of Organic Chemistry*, 23(12), 1977–1979.
26. Benington, F., Morin, R. D., Clark, L. C., & Fox, R. P. (1958). Psychopharmacological Activity of Ring- and Side Chain-Substituted β -Phenethylamines¹. *Journal of Organic Chemistry*, 23(12), 1979–1984.
27. Benington, F., Morin, R. D., & Clark, L. C. (1959). Synthesis of 5,6,7-Trimethoxy-2,3-dihydroindole and 6,7-Dimethoxyindole. *Journal of Organic Chemistry*, 24(7), 917–919.
28. Benington, F. (1959). [Preliminary Identification of Crystalline Phases in a Transparent Stalactite](#). *Science*, 129 3357, 1227 .
29. Benington, F., Morin, R. D., & Clark, L. C. (1960). Synthesis of Some 5- and 6-Chloro, 5-Methyl, and 5,6,7-Trimethyl Derivatives of Tryptamine. *Journal of Organic Chemistry*, 25(9), 1542–1547.
30. Benington, F., Morin, R. D., & Clark, L. C. (1960). Synthesis of Some Vicinal Trimethoxyphenyl Derivatives of Heterocyclic Nitrogen Bases. *Journal of Organic Chemistry*, 25(11), 1912–1916.
31. Benington, F., Morin, R., & Clark, L. (1960). Notes- Mescaline Analogs. X. 3,4-Dimethyl-, 3,4-Dichloro- and 3,5-Dimethoxy-4-methyl- β -phenethylamines. *Journal of Organic Chemistry*, 25(11), 2066–2067.
32. Benington, F., & Morin, R. D. (1961). Cyclization of Some O-Substituted Derivatives of N-(3,4-Dimethoxy- β -phenylethyl)glycolamide; Synthesis of (\pm)-Calycotomine. *Journal of Organic Chemistry*, 26(1), 194–197.
33. Benington, F., & Morin, R. D. (1961). Pyrolysis of cis- and trans-3-Hexenedioic Acids. *Journal of Organic Chemistry*, 26(12), 5210–5212.

34. Benington, F., & Morin, R. D. (1962). Contribution to the Structure of Falcatine. Synthesis of Isoanhydrofalcatine Lactam. *Journal of Organic Chemistry*, 27(1), 142–146.
35. Benington, F., Melton, C., & Watson, P.J. (1962). Carbon Dating Prehistoric Soot from Salts Cave. *American Antiquity*, 28 2, 238-41
36. Benington, F., Morin, RD., & Clark, L.C.. (1964). Pharmacological Activity of Phenylisopropylhydroxylamine and its O-Methyl Ether. **Nature**, 202(4934), 813–813.
37. Clark, L.C., Benington, F., & Morin, R.D. (1964). THE ENZYMATIC OXIDATIVE DEAMINATION AND EFFECT ON CAT BEHAVIOR MESCALINE AND STRUCTURALLY-RELATED BETA-PHENETHYLAMINES. *The Alabama journal of medical sciences*, 1, 417-29 .
38. Benington, F., Morin, RD., & Clark, L.C.. (1965). BEHAVIORAL AND NEUROPHARMACOLOGICAL ACTIONS OF N-ARALKYLHYDROXYLAMINES AND THEIR O-METHYL ETHERS. *Journal of Medicinal Chemistry*, 8(1), 100–104.
39. Clark, L.C., Benington, F., & Morin, R.D. (1965). THE EFFECTS OF RING-METHYOXYL GROUPS ON BIOLOGICAL DEAMINATION OF PHENETHYLAMINES. *Journal of medicinal chemistry*, 8, 353-5 .
40. Benington, F., Morin, R.D., & Clark, L.C. (1965). 5-methoxy-N, N-dimethyltryptamine, a possible endogenous psychotoxin. *The Alabama journal of medical sciences*, 2 4, 397-403 .
41. Smythies, J.R., Bradley, R.J., Johnston, V.S., Benington, F., Morin, R.D., & Clark, L.C. (1967). Structure-activity relationship studies on mescaline. *Psychopharmacologia*, 10, 379-387.
42. Smythies, J. R., R. J. Bradley, V. S. Johnston, F. Benington, R. D. Morin, and L. C. Clark Jr. 1967. "Structure-Activity Relationship Studies on Mescaline III. The Influence of the Methoxy Groups." *Psychopharmacology* 10 (5): 379–87.
43. Benington, Frederick, and Richard D. Morin. 1967. "Synthesis of (.+.)-Cryptowoline Iodide." *Journal of Organic Chemistry* 32 (4): 1050–53.
44. Smythies, J. R., V. S. Johnston, R. J. Bradley, F. Benington, R. D. Morin, and L. C. Clark. 1967. "Some New Behaviour-Disrupting Amphetamines and Their Significance." **Nature** 216 (5111): 128–29. <https://doi.org/10.1038/216128A0>
45. Benington, F., & Morin, R.D. (1968). Enzymatic 5-hydroxylation of 3-methoxytyramine. *Experientia*, 24, 33-34.
46. Benington, F., & Morin, R.D. (1968). The chemorelease of norepinephrine from mouse hearts by substituted amphetamines. *Journal of medicinal chemistry*, 11 4, 896-7 .
47. Beaton, J. M., John R. Smythies, F. Benington, R. D. Morin, and L. C. Clark jun. 1968. "Behavioural Effects of Some 4-Substituted Amphetamines." **Nature** 220 (5169): 800–801. <https://doi.org/10.1038/220800A0>
48. Smythies, J.R., Benington, F., & Morin, R.D. (1970). The mechanism of action of hallucinogenic drugs on a possible serotonin receptor in the brain. *International review of neurobiology*, 12, 207-33 .
49. Smythies, J. R., Beaton, J., Benington, F., & Morin, R. D. (1970). Behavioural Effects of some Derivatives of Amphetamine and LSD and their Significance. **Nature**, 226(5246), 644–645. <https://doi.org/10.1038/226644A0>
50. Antun, F., Smythies, J. R., Benington, F., Morin, R. D., Barfknecht, C. F., & Nichols, D. E. (1971). Native fluorescence and hallucinogenic potency of some amphetamines. *Cellular and Molecular Life Sciences*, 27(1), 62–63.
51. Benington, F., & Morin, R.D. (1971). Synthesis of 2,3,6-trimethoxy-beta-phenethylamine. *Journal of medicinal chemistry*, 14 4, 375-6 .

52. Smythies, J. R., Benington, F., & Morin, R. D. (1971). Model for the Action of Tetrodotoxin and Batrachotoxin. **Nature**, 231(5299), 188–190. <https://doi.org/10.1038/231188A0>
53. Benington, F., & Morin, R. D. (1971). DIE SYNTHESE VON 2,3,6-TRIMETHOXY-BETA-PHENAETHYLAMIN. *ChemInform*, 2(30).
54. Smythies, J. R., Benington, F., & Morin, R. D. (1972). Encephalitogenic protein: A β -pleated sheet conformation (102–120) yields a possible molecular form of a serotonin receptor. *Cellular and Molecular Life Sciences*, 28(1), 23–24.
55. Smythies, J.R., Beaton, J.M., Benington, F., & Morin, R.D. (1972). The design of some new compounds to block psychotomimetic drugs. *European journal of pharmacology*, 17 2, 270-2 .
56. Smythies, J.R., Benington, F., & Morin, R.D. (1972). A mechanism for the interaction of a histone and DNA. *Journal of theoretical biology*, 37 1, 151-8 .
57. Smythies, J. R., Benington, F., & Morin, R. D. (1972). On the molecular mechanism of action of the tetracyclines. *Cellular and Molecular Life Sciences*, 28(10), 1253–1254.
58. Benington, F., Morin, R.D., Beaton, J.M., Smythies, J.R., & Bradley, R.J. (1973). [Comparative effects of stereoisomers of hallucinogenic amphetamines](#). **Nature: New biology**, 242 119, 185-6 . (Letter)
59. Nichols, D.E., Barfknecht, C.F., Rusterholz, D.B., Benington, F., & Morin, R.D. (1973). Asymmetric synthesis of psychotomimetic phenylisopropylamines. *Journal of medicinal chemistry*, 16 5, 480-3 .
60. Benington, F., & Morin, R. D. (1973). METHYLAMINOACETONE ETHYLENE KETAL HYDROCHLORIDE. *Organic Preparations and Procedures International*, 5(6), 281–284.
61. Smythies, J.R., Benington, F., Bradley, R.J., Bridgers, W.F., & Morin, R.D. (1974). On the molecular mechanism of action of scorpion neurotoxin. II. From *Androctonus australis* Hector. *Journal of theoretical biology*, 43 1, 65-72 .
62. Smythies, J.R., Benington, F., Bradley, R.J., Morin, R.D., & Romine, W.O. (1974). On the mechanism of interaction between histone II B1 and DNA and histone II B2 and DNA. *Journal of theoretical biology*, 47 2, 383-95 .
63. Smythies, J.R., Benington, F., Bradley, R.J., Bridgers, W.F., & Morin, R.D. (1974). The molecular structure of the sodium channel. *Journal of theoretical biology*, 43 1, 29-42 .
64. Benington, F., & Morin, R.D. (1974). METHYLAMINOACETONE ETHYLEN KETAL HYDROCHLORIDE.
65. Smythies, J.R., Benington, F., Bradley, R.J., Morin, R.D., & Romine, W.O. (1974). On the mechanism of interaction between histone I and DNA and histone III and DNA. *Journal of theoretical biology*, 47 2, 309-15 .
66. Benington, F., & Morin, R.D. (1974). Enzymatic 5-hydroxylation of 3,4-dimethoxy-beta-phenethylamine. *The Alabama journal of medical sciences*, 11 4, 354-5 .
67. Smythies, J. R., Benington, F., & Morin, R. D. (1975). ON THE MOLECULAR STRUCTURE OF RECEPTORS FOR CO-CARCINOGENS AND SOME ANTI-CANCER DRUGS. *Psychoneuroendocrinology*, 1(2), 123–130.
68. Morin, R. D., Benington, F., Mitchell, S. R., Beaton, J. M., Bradley, R. J., & Smythies, J. R. (1975). The behavioral effects of 2,5-dimethoxy-4-alkyl amphetamines. *Cellular and Molecular Life Sciences*, 31(1), 93–95.
69. Christian, S.T., Benington, F., Morin, R.D., & Corbett, L. (1975). Gas-liquid chromatographic separation and identification of biologically important indolealkylamines from human cerebrospinal fluid. *Biochemical medicine*, 14 2, 191-200 .

70. Smythies, J.R., Benington, F., Morin, R.D., Al-Zahid, G., & Schoepfle, G.M. (1975). The action of the alkaloids from yew (*Taxus baccata*) on the action potential in the *Xenopus* medullated axon. *Experientia*, 31, 337-338.
71. Benington, F., Christian, S.T., & Morin, R.D. (1975). Identification and separation of indolealkylamines by gas-liquid chromatographic analysis of their heptafluorobutyryl derivatives. *Journal of chromatography*, 106 2, 435-9 .
72. Smythies, J.R., Benington, F., Bradley, R.J., Bridgers, W.F., Morin, R.D., & Romine, W.O. (1975). The molecular structure of the receptor-ionophore complex at the neuromuscular junction. *Journal of theoretical biology*, 51 1, 111-26 .
73. Christian, S.T., McClain, L.D., Morin, R.D., & Benington, F. (1975). Blockage of LSD binding at its high affinity site on synaptosomal membranes by 1-methyl-1,2,5,6-tetrahydropyridine-N,N-diethyl-carboxamide. *Experientia*, 31, 910-911.
74. Dyer, D.C., Benington, F., & Morin, R.D. (1975). Antagonism of d-lysergic acid diethylamide and mescaline by 1-methyl-1, 2, 5, 6-tetrahydropyridine-N, N-diethyl-carboxamide (THPC). *Archives internationales de pharmacodynamie et de therapie*, 217 2, 197-200 .
75. Christian, S.T., Benington, F., Morin, R.D., & Corbett, L. (1975). Gas-liquid chromatographic separation and identification of biologically important indolealkylamines from human cerebrospinal fluid. *Biochemical medicine*, 14 2, 191-200 .
76. Smythies, J.R., Benington, F., & Morin, R.D. (1975). On the molecular structure of receptors for co-carcinogens and some anti-cancer drugs. *Psychoneuroendocrinology*, 1, 123-130.
77. Beaton, J.M., Benington, F., Bradley, R.J., Kuhlemeier, K.V., & Morin, R.D. (1976). Stereospecific actions of 2,5-dimethoxy-4-methylamphetamine (DOM) on colonic temperature in the rat at various ambient temperatures. *British journal of pharmacology*, 57 4, 547-50 .
78. Benington, F., Morin, R. D., & Bradley, R. J. (1976). 7-(N,N-trimethyl)-5-methoxytryptamine. *Journal of Heterocyclic Chemistry*, 13(4), 749-751.
79. Smythies, J.R., Beaton, J.M., Benington, F., Bradley, R.J., & Morin, R. (1976). On the molecular mechanism of interaction between the neurophysins and oxytocin and vasopressin. *Journal of theoretical biology*, 63 1, 33-48 .
80. Smythies, J.R., Benington, F., Bradley, R.J., & Morin, R.D. (1977). A molecular mechanism of action of scorpion neurotoxins. *The Alabama journal of medical sciences*, 14 1, 68-74 .
81. Corbett, L., Christian, S.T., Morin, R.D., Benington, F., & Smythies, J.R. (1978). Hallucinogenic N-methylated indolealkylamines in the cerebrospinal fluid of psychiatric and control populations. *The British journal of psychiatry : the journal of mental science*, 132, 139-44 .
82. Barker, S.A., Monti, J.A., Christian, S.T., Benington, F., & Morin, R.D. (1980). 9-Diazomethylanthracene as a new fluorescence and ultraviolet label for the spectrometric detection of picomole quantities of fatty acids by high-pressure liquid chromatography. *Analytical biochemistry*, 107 1, 116-23 .
83. Glennon, R.A., Young, R., Benington, F., & Morin, R.D. (1982). Hallucinogens as discriminative stimuli: a comparison of 4-OMe DMT and 5-OMe DMT with their methythio counterparts. *Life sciences*, 30 5, 465-7 .
84. Kline, T.B., Benington, F., Morin, R.D., & Beaton, J.M. (1982). Structure-activity relationships in potentially hallucinogenic N,N-dialkyltryptamines substituted in the benzene moiety. *Journal of medicinal chemistry*, 25 8, 908-13 .
85. Kline, T.B., Benington, F., Morin, R.D., Beaton, J.M., Glennon, R.A., Domelsmith, L.N., Houk, K.N., & Rozeboom, M.D. (1982). Structure-activity relationships for hallucinogenic

- N,N-dialkyltryptamines: photoelectron spectra and serotonin receptor affinities of methylthio and methylenedioxy derivatives. *Journal of medicinal chemistry*, 25 11, 1381-3 .
86. Glennon, R.A., Young, R., Benington, F., & Morin, R.D. (1982). Behavioral and serotonin receptor properties of 4-substituted derivatives of the hallucinogen 1-(2,5-dimethoxyphenyl)-2-aminopropane. *Journal of medicinal chemistry*, 25 10, 1163-8 .
87. Barker, S.A., Monti, J.A., Christian, S.T., Benington, F., & Morin, R.D. (1983). Preparation of 9-diazomethylantracene. *Analytical biochemistry*, 132 2, 456 .
88. Benington, F., Morin, R. D., & Khaled, M. A. (1984). An efficient procedure for the synthesis of trans-2-, -3-, and -4-pyridalacetones. *Synthesis*, 1984(7), 619–620.
89. Khaled, M.A., Morin, R.D., Benington, F., & Daugherty, J.P. (1984). 2,4-Diamino-6-(bis-2-chloroethyl)aminomethyl pteridine. *Cancer Chemotherapy and Pharmacology*, 13, 73-74.
90. Khaled, M. A., Benington, F., & Morin, R. D. (1986). Pteridine derivatives and method of treating leukemia employing same.[US Patent 4,820,706 April 11 1989, assigned to Research Corporation (New York, NY)]