# JOHN F. NASH, JR.

## Autobiography

My beginning as a legally recognized individual occurred on June 13, 1928 in Bluefield, West Virginia, in the Bluefield Sanitarium, a hospital that no longer exists. Of course I can't consciously remember anything from the first two or three years of my life after birth. (And, also, one suspects, psychologically, that the earliest memories have become "memories of memories" and are comparable to traditional folk tales passed on by tellers and listeners from generation to generation.) But facts are available when direct memory fails for many circumstances.

My father, for whom I was named, was an electrical engineer and had come to Bluefield to work for the electrical utility company there which was and is the Appalachian Electric Power Company. He was a veteran of WWI and had served in France as a lieutenant in the supply services and consequently had not been in actual front lines combat in the war. He was originally from Texas and had obtained his B.S. degree in electrical engineering from Texas Agricultural and Mechanical (Texas A. and M.).

My mother, originally Margaret Virginia Martin, but called Virginia, was herself also born in Bluefield. She had studied at the University of West Virginia and was a school teacher before her marriage,

teaching English and sometimes Latin. But my mother's later life was considerably affected by a partial loss of hearing resulting from a scarlet fever infection that came at the time when she was a student at WVU.

Her parents had come as a couple to Bluefield from their original homes in western North Carolina. Her father, Dr. James Everett Martin, had prepared as a physician at the University of Maryland in Baltimore and came to Bluefield, which was then expanding rapidly in population, to start up his practice. But in his later years Dr. Martin became more of a real estate investor and left actual medical practice. I never saw my grandfather because he had died before I was born but I have good memories of my grandmother and of how she could play the piano at the old house which was located rather centrally in Bluefield.

A sister, Martha, was born about two and a half years later than me, on November 16, 1930.

I went to the standard schools in Bluefield but also to a kindergarten before starting in the elementary school level. And my parents provided an encyclopedia, Compton's Pictured Encyclopedia, that I learned a lot from by reading it as a child. And also there were other books available from either our house or the house of the grandparents that were of educational value.

Bluefield, a small city in a comparatively remote geographical location in the Appalachians, was not a community of scholars or of high technology. It was a center of businessmen, lawyers, etc. that owed its existence to the railroad and the rich nearby coal fields of West Virginia and western Virginia. So, from the intellectual viewpoint, it offered the sort of challenge that one had to learn from the world's knowledge rather than from the knowledge of the immediate community.

By the time I was a student in high school I was reading the classic "Men of Mathematics" by E. T. Bell and I remember succeeding in proving the classic Fermat theorem about an integer multiplied by itself p times where p is a prime.

I also did electrical and chemistry experiments at that time. At first, when asked in school to prepare an essay about my career, I prepared one about a career as an electrical engineer like my father. Later, when I

actually entered Carnegie Tech. in Pittsburgh I entered as a student with the major of chemical engineering.

Regarding the circumstances of my studies at Carnegie (now Carnegie Mellon U.), I was lucky to be there on a full scholarship, called the George Westinghouse Scholarship. But after one semester as a chem. eng. student I reacted negatively to the regimentation of courses such as mechanical drawing and shifted to chemistry instead. But again, after continuing in chemistry for a while I encountered difficulties with quantitative analysis where it was not a matter of how well one could think and understand or learn facts but of how well one could handle a pipette and perform a titration in the laboratory. Also the mathematics faculty were encouraging me to shift into mathematics as my major and explaining to me that it was not almost impossible to make a good career in America as a mathematician. So I shifted again and became officially a student of mathematics. And in the end I had learned and progressed so much in mathematics that they gave me an M.S. in addition to my B.S. when I graduated.

I should mention that during my last year in the Bluefield schools my parents had arranged for me to take supplementary math. courses at Bluefield College, which was then a 2-year institution operated by Southern Baptists. I didn't get official advanced standing at Carnegie because of my extra studies but I had advanced knowledge and ability and didn't need to learn much from the first math. courses at Carnegie.

When I graduated I remember that I had been offered fellowships to enter as a graduate student at either Harvard or Princeton. But the Princeton fellowship was somewhat more generous since I had not actually won the Putnam competition and also Princeton seemed more interested in getting me to come there. Prof. A. W. Tucker wrote a letter to me encouraging me to come to Princeton and from the family point of view it seemed attractive that geographically Princeton was much nearer to Bluefield. Thus Princeton became the choice for my graduate study location.

But while I was still at Carnegie I took one elective course in "International Economics," and as a result of that exposure to economic ideas and problems arrived at the idea that led to the paper "The Bargaining

Problem" which was later published in Econometrica. And it was this idea which in turn, when I was a graduate student at Princeton, led to my interest in the game theory studies there which had been stimulated by the work of von Neumann and Morgenstern.

As a graduate student I studied mathematics fairly broadly and I was fortunate enough, besides developing the idea which led to "Non-Cooperative Games," also to make a nice discovery relating to manifolds and real algebraic varieties. So I was prepared actually for the possibility that the game theory work would not be regarded as acceptable as a thesis in the mathematics department and then that I could realize the objective of a Ph.D. thesis with the other results.

But in the event the game theory ideas, which deviated somewhat from the "line" (as if of "political party lines") of von Neumann and Morgenstern's book, were accepted as a thesis for a mathematics Ph.D. and it was later, while I was an instructor at M.I.T., that I wrote up "Real Algebraic Manifolds" and sent it in for publication.

I went to M.I.T. in the summer of 1951 as a "C.L.E. Moore Instructor." I had been an instructor at Princeton for one year after obtaining my degree in 1950. It seemed desirable more for personal and social reasons than academic ones to accept the higher-paying instructorship at M.I.T.

I was on the mathematics faculty at M.I.T. from 1951 until I resigned in the spring of 1959. During the academic year 1956–1957 I had an Alfred P. Sloan grant and chose to spend the year as a (temporary) member of the Institute for Advanced Study in Princeton.

During this period of time I managed to solve a classical unsolved problem relating to differential geometry which was also of some interest in relation to the geometric questions arising in general relativity. This was the problem to prove the isometric embeddability of abstract Riemannian manifolds in flat (or "Euclidean") spaces. But this problem, although classical, was not much talked about as an outstanding problem. It was not like, for example, the 4-color conjecture.

So as it happened, as soon as I heard in conversation at M.I.T. about the question of the embeddability being open I began to study it. The first break led to a curious result about the embeddability being realizable in surprisingly low-dimensional ambient spaces provided that one

would accept that the embedding would have only limited smoothness. And later, with "heavy analysis," the problem was solved in terms of embeddings with a more proper degree of smoothness.

While I was on my "Sloan sabbatical" at the IAS in Princeton I studied another problem involving partial differential equations which I had learned of as a problem that was unsolved beyond the case of 2 dimensions. Here, although I did succeed in solving the problem, I ran into some bad luck since, without my being sufficiently informed on what other people were doing in the area, it happened that I was working in parallel with Ennio de Giorgi of Pisa, Italy. And de Giorgi was first actually to achieve the ascent of the summit (of the figuratively described problem), at least for the particularly interesting case of "elliptic equations."

It seems conceivable that if either de Giorgi or Nash had failed in the attack on this problem (of a priori estimates of Hölder continuity) then the lone climber reaching the peak would have been recognized with mathematics' Fields medal (which has traditionally been restricted to persons less than 40 years old).

Now I must arrive at the time of my change from scientific rationality of thinking into the delusional thinking characteristic of persons who are psychiatrically diagnosed as "schizophrenic" or "paranoid schizophrenic." But I will not really attempt to describe this long period of time but rather avoid embarrassment by simply omitting to give the details of truly personal type.

While I was on the academic sabbatical of 1956–1957 I also entered into marriage. Alicia had graduated as a physics major from M.I.T. where we had met and she had a job in the New York City area in 1956–1957. She had been born in El Salvador but came at an early age to the U.S. and she and her parents had long been U.S. citizens, her father being an M.D. and ultimately employed at a hospital operated by the federal government in Maryland.

The mental disturbances originated in the early months of 1959 at a time when Alicia happened to be pregnant. And as a consequence I resigned my position as a faculty member at M.I.T. and ultimately, after spending 50 days under "observation" at the McLean Hospital, travelled to Europe and attempted to gain status there as a refugee.

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I later spent times of the order of five to eight months in hospitals in New Jersey, always on an involuntary basis and always attempting a legal argument for release.

And it did happen that when I had been long enough hospitalized I would finally renounce my delusional hypotheses and revert to thinking of myself as a human of more conventional circumstances and return to mathematical research. In these interludes of, as it were, enforced rationality, I did succeed in doing some respectable mathematical research. Thus there came about the research for "Le Problème de Cauchy pour les Équations Différentielles d'un Fluide Générale"; the idea that Prof. Hironaka called "the Nash blowing-up transformation"; and those of "Arc Structure of Singularities" and "Analyticity of Solutions of Implicit Function Problems with Analytic Data."

But after my return to the dream-like delusional hypotheses in the later '60s I became a person of delusionally influenced thinking but of relatively moderate behavior and thus tended to avoid hospitalization and the direct attention of psychiatrists.

Thus further time passed. Then gradually I began to intellectually reject some of the delusionally influenced lines of thinking which had been characteristic of my orientation. This began, most recognizably, with the rejection of politically-oriented thinking as essentially a hopeless waste of intellectual effort.

So at the present time I seem to be thinking rationally again in the style that is characteristic of scientists. However this is not entirely a matter of joy as if someone returned from physical disability to good physical health. One aspect of this is that rationality of thought imposes a limit on a person's concept of his relation to the cosmos. For example, a non-Zoroastrian could think of Zarathustra as simply a madman who led millions of naive followers to adopt a cult of ritual fire worship. But without his "madness" Zarathustra would necessarily have been only another of the millions or billions of human individuals who have lived and then been forgotten.

Statistically, it would seem improbable that any mathematician or scientist, at the age of 66, would be able through continued research efforts, to add much to his or her previous achievements. However I am

still making the effort and it is conceivable that with the gap period of about 25 years of partially deluded thinking providing a sort of vacation my situation may be atypical. Thus I have hopes of being able to achieve something of value through my current studies or with any new ideas that come in the future.

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