

# Benoit Mandelbrot

(November 20, 1924 - October 14, 2010)

By Peter Liljedahl

On October 14, 2010, at the age of 85 the mathematical community lost Benoit Mandelbrot, well known as the father of fractal geometry. As the creator of our most famous contemporary mathematical image – the Mandelbrot set – Mandelbrot had few rivals in the category of mathematicians whose work was recognized (if not understood) by the general public.

In 2002 I had the pleasure of interacting with Mandelbrot through a series of email exchanges about his thoughts on mathematical creativity and the AHA! experience. These exchanges, along with similar exchanges with 25 other prominent research mathematicians, were designed and implemented as part of a research project to build a greater understanding of the mathematical mind vis-à-vis the creation and discovery of mathematics. This research was modeled on the work of Jacques Hadamard who, in 1943, gave a series of lectures on mathematical invention at the Ecole Libre des Hautes Etudes in New York City. These talks were subsequently published as *The Psychology of Mathematical Invention in the Mathematical Field* (Princeton University Press).

Hadamard's seminal work outlines the beliefs of contemporary mathematicians as to the mechanism by which they come to create new mathematics. He based his survey on an earlier one that was published in the periodical *L'Enseignement Mathématique* (Vol. I, 1902 and Vol. VI, 1904). Hadamard was critical of this earlier survey in that it failed to solicit the views of "mathematicians whose creative processes are worthy of interest" (Hadamard, p.10). Hadamard set excellence in the field of mathematics as a criterion for participation in his study. In keeping with Hadamard's standards I chose to survey the most prominent mathematicians (Fields medallists, Nevanlinna Prize winners, and members of: The Royal Society, American Society of Arts & Sciences, and the Academie des Sciences). Mandelbrot was such a mathematician.

Rather than go into the life history of Benoit Mandelbrot, or the nuances and relationships between fractal geometry, fractional dimension, and the Mandelbrot set, I thought it would be interesting to instead publish here Mandelbrot's thoughts on the creation and discovery of mathematics. Although excerpts of these thoughts have been published in a number of research articles, as well as a forthcoming MAA book on the subject, this is the first time they have been published in their entirety.

*It happens that I knew Hadamard personally since an uncle of mine was his successor at College de France. I also read and liked his "creativity" book. In addition, please understand that the mathematicians you are "polling" were largely trained in the 1950s or 1960s. Among them I am very atypical*

*and may be the person whose view of mathematics is farthest from the “norms” of yesterday and closest to Hadamard’s.*

Would you say that your principle discoveries have been the result of deliberate endeavour in a definite direction, or have they arisen, so to speak, spontaneously? Have you a specific anecdote of a moment of insight/inspiration/illumination that would demonstrate this?

*Most definitely. My principal discoveries have arisen “spontaneously.” Also, nearly everyone was perceived as a change of direction, in fact their topics were first reputed to wander all around. But every so often there was a spurt of after-the-fact “self-organization” and reorganization that affected future progress. One major spurt occurred in 1973 and led to a new concept (and also a new word), namely, fractal geometry. The latest spurt occurred recently: fifty years after my Ph.D. thesis, I realized that fractal geometry is the long awaited theory of roughness in its mathematical and other aspects.*

How much of mathematical creation do you attribute to chance, insight, inspiration, or illumination? Have you come to rely on this in any way?

*Was insight important? Constantly, but it may well be that one major insight was already reflected in my Ph.D. thesis was of endless benefit. Do I experience feelings of illumination? Rarely, except in connection with chance, whose offerings I treasure. In my wandering life between concrete fields and problems, chance is continually important in two ways. A chance reading or encounter has often brought an awareness of existing mathematical tools that were new to me and allowed me to return to old problems I was previously obliged to leave aside. In other cases, a chance encounter suggested that old tools could have new uses that helped them expand.*

Could you comment on the differences in the manner in which you work when you are trying to assimilate the results of others (learning mathematics) as compared to when you are indulging in personal research (creating mathematics)?

*There is not much difference. More precisely, I seldom study or learn mathematics in detail. On occasion, I merely quote some existing result that I trust. When there is a need to fully assimilate something, I must redo everything in my own way.*

Have your methods of learning and creating mathematics changed since you were a student? How so?

*My methods of work show no real change, in fact – against every cliché – a steady improvement that may still continue at age 77.*

Among your greatest works have you ever attempted to discern the origin of the ideas that lead you to your discoveries? Could you comment on the creative process that lead you to your discoveries?

*My passion for the history of ideas is boundless and I go to endless lengths, not to hide the influences from which I benefited, but to understand and express them thoroughly. To me, the value of a thought combines its novelty and difficulty with the depth of its roots. The greatest thrill is to add to streams of ideas that already have a long and recognizable past. As to my creative process, the sole peculiar feature that is identifiable, significant and worthy reporting is the essential role the eye continues to play. Hadamard would have understood this very well. But in my working life, I may, from this viewpoint, be unique.*