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**ONE HUNDRED REASONS
TO BE A SCIENTIST**



TRIESTE

2004

ITALY

ROUGH, LONELY AND EXCITING

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Landowners' or bankers' children have an easy option when they "grow up:" they had been prepared over many years to follow the family tradition. My family owned neither land nor bank but did have a strong tradition: I was expected without saying to become a scholar of some sort. Any other activity would have required a specific reason. Did this molding make my choice any easier? It did not; in fact, I found growing up very complicated, first, because the effects of the Depression and World War II, but later because of sharply conflicting advice from my father and his youngest brother.

I was thirteen when my uncle became a professor at the famed Collège de France in Paris; hence I always knew that respected, comfortable, and altogether enjoyable professions included pure mathematics. Since I had a quick mind and good grades, the option of following after my uncle was widely open. But it encountered strong obstacles. First, Father was very strongly opposed; besides, his influence and what I

kept reading over the years had instilled in me a powerful opposite interest, not in the simplicity of mathematics but in complex down-to-earth issues, for example, how complex machines work. Secondly, constant interruptions in my schooling had left me only a middling performer in analytic manipulations. On the other hand, when I was nineteen, a few crucial weeks revealed that I had a rare and powerful native gift: I could carry out in my head complicated mathematical arguments directly in terms of geometric shapes. Absent the war, more organized and exacting training in analysis might have diluted this almost freakish gift, or prevented it from manifesting itself, or even encouraged me away from science. As things stood when I turned twenty, none of the obvious paths open to me matched my tastes. I had also antagonized several well-meaning persons by not following their advice.

The resulting complexity of my professional life continually reflected the topic I went on to pioneer, namely, complexity in the real world. In 1950, this was a completely uncharted domain but I was lucky to be living in relatively free-wheeling times. This allowed greater risk taking than would be reasonable today. Entrepreneurs are more familiar than scientists with high risk and the paradox that a high-risk taker who wants to survive and continue must not be reckless but cautious. In a way, I was very conservative and began as a "misfit" but made myself over into a "maverick."

Actually, the word “complexity” did not enter scientific discourse until much later. Also, being a conservative high risk-taker deprived me of role models. Running against every trend, I did not even think of seeking principles that could be developed into a theory, from top down. Instead, I started by seemingly narrow problems and the steps I took began by being small and moved to being increasingly bold. Most significantly, I never underestimated the complexity of the real world and simplified it from the outset—without distorting it—by only paying attention to its most visible aspect, namely, roughness and fragmentation. Despite this limitation, much work was done. But much remains to be done because roughness is absolutely ubiquitous and often is the major obstacle to an understanding and control of reality.

For the nascent theory of roughness, browsing through a Latin dictionary made me coin a new term, “fractal geometry.” Its development went beyond anyone’s wildest hopes. It raised questions of pure mathematics that enchant, challenge, and often continue to frustrate the experts. It gave hope that a physics of roughness may soon arise next to the well-established studies of weight, motion, light, and sound. It tamed the complexity of physical clusters of all kinds. It came far closer to truth than any alternative model of financial price variation. It provided a major theme to the earth sciences. It yielded stunning graphics. It led to the discovery that examples of fractality that no one had previously recognized as such had been included in art and architecture since time immemorial.

My long ride through these activities has been rough and often lonely—but exciting. If given the same chance, would I want to repeat it? Yes, but no one is ever given the same chance. Should others try to repeat it? Certainly not, but two lessons I learned are worth sharing. Those who dare predict future manpower needs are biased, do not know enough, and are seldom right. To rush and narrow yourself down to fit their advice seems the safest path, but in fact is the most dangerous. To perfect the skills you have and love is by far the best beginning—as long as your skills keep broadening rather than narrowing. Once educated in the science you love, you may easily move to another or to a different path. But you could never catch up on science. Do you want your life to make a difference? More than ever, science—like all other aspects of society—needs young adherents who combine wide knowledge with a disciplined willingness to take high risks—both for their own personal satisfaction and the moral welfare of the human race.

In this collection of about 100 highly readable essays, some of the most eminent physicists and mathematicians with some connection to ICTP tell us about what attracted them to science as youngsters and kept it alive, and what main piece of knowledge they have added to the extraordinary lore of science. High school students and young college students, for whom the collection is primarily meant, will benefit from spending some time with the book. Even the most seasoned researcher will find it interesting.

- from the preface

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