

on *How to Play Chess*. Znosko-Borowsky created a mild sensation by writing one called *How Not to Play Chess*.

Rules for Discovery

I suspect that my chapter on problem-solving would be heavily obligated to a little book by George Polya, first published in 1945, called *How to Solve It*.

Polya's book is devoted primarily to the problem of solving problems in mathematics; but it is applicable over the whole field of invention, discovery, and independent thinking.

"A great discovery," the author tells us in the preface, "solves a great problem but there is a grain of discovery in the solution of any problem. Your problem may be modest, but if it challenges your curiosity and brings into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. Such experiences at a susceptible age may create a taste for mental work and leave their imprint on mind and character for a lifetime."

Polya has all sorts of instructive things to say about what questions to ask — "What is the unknown?" — about the uses of analogy, about "decomposing" and "recomposing" problems, about Descartes' rules for invention,

about the indispensability of good symbols and good notation for mathematical thinking. He tells how, overnight or after a longer interval, our subconscious mind will often solve problems for us, but warns that "conscious effort and tension seem to be necessary to set the subconscious work going" — otherwise everything would be too easy.

Polya calls his whole book an effort to teach *Heuristic*: "The aim of heuristic is to study the methods and rules of discovery and invention. . . . The most famous attempts to build up a system of heuristic are due to Descartes and to Leibnitz, both great mathematicians and philosophers."

Polya's own illustrations and application are confined entirely to mathematics, for which his own enthusiasm is contagious. The reader, he says, should at least try to find out whether he has a taste for mathematics, and he may find out that "a mathematics problem may be as much fun as a crossword puzzle, or that vigorous mental work may be an exercise as desirable as a fast game of tennis. Having tasted the pleasure in mathematics he will not forget it easily and then there is a good chance that mathematics will become something for him: a hobby, or a tool of his profession, or his profession, or a great ambition."

Conscious effort and tension seem to be necessary to set the subconscious work going.
—Polya

Specialization, Perseverance, Analogy

My new book would contain a chapter on "The Dilemma of Specialization." The dilemma is this. In the modern world knowledge has been growing so fast and so enormously, in almost every field, that the probabilities are immensely against anybody, no matter how innately clever, being able to make a contribution in any one field unless he devotes all his time to it for years. If he tries to be the Rounded Universal Man, like Leonardo da Vinci, or to take all knowledge for his province, like Francis Bacon, he is most likely to become a mere dilettante and dabbler. But if he becomes too specialized, he is apt to become narrow and lopsided, ignorant on every subject but his own, and perhaps dull and sterile even on that because he lacks perspective and vision and has missed the cross-fertilization of ideas that can come from knowing something of other subjects.

I do not know the way out of this dilemma, or the exact compromise, but I hope to find it by the time I write my new book.

My new book, like the present

one, will have a chapter on concentration, but it is more likely to be called "Concentration and Perseverance," for it will put far more emphasis on patience, plodding, perspiration, pertinacity, determination, effort, *work* — on again and again returning to an obstinate problem until it is solved. Scientists talk much nowadays of "serendipity" — the faculty of making desirable discoveries by accident. An example often cited is how Sir Alexander Fleming discovered penicillin because one of his laboratory technicians had carelessly left the top off a dish in which a virulent infectious organism, staphylococcus, was growing; a number of fungi had floated into the open dish, overgrown the bacteria — and killed it. The accident led Fleming to his discovery. But these "accidents" only seem to bear fruit when they happen to alert indefatigable scientists who have already been working for years on a project. As Pasteur put it: "Chance favors the prepared mind."

In my new book I would treat *Analogy* less cavalierly than I did