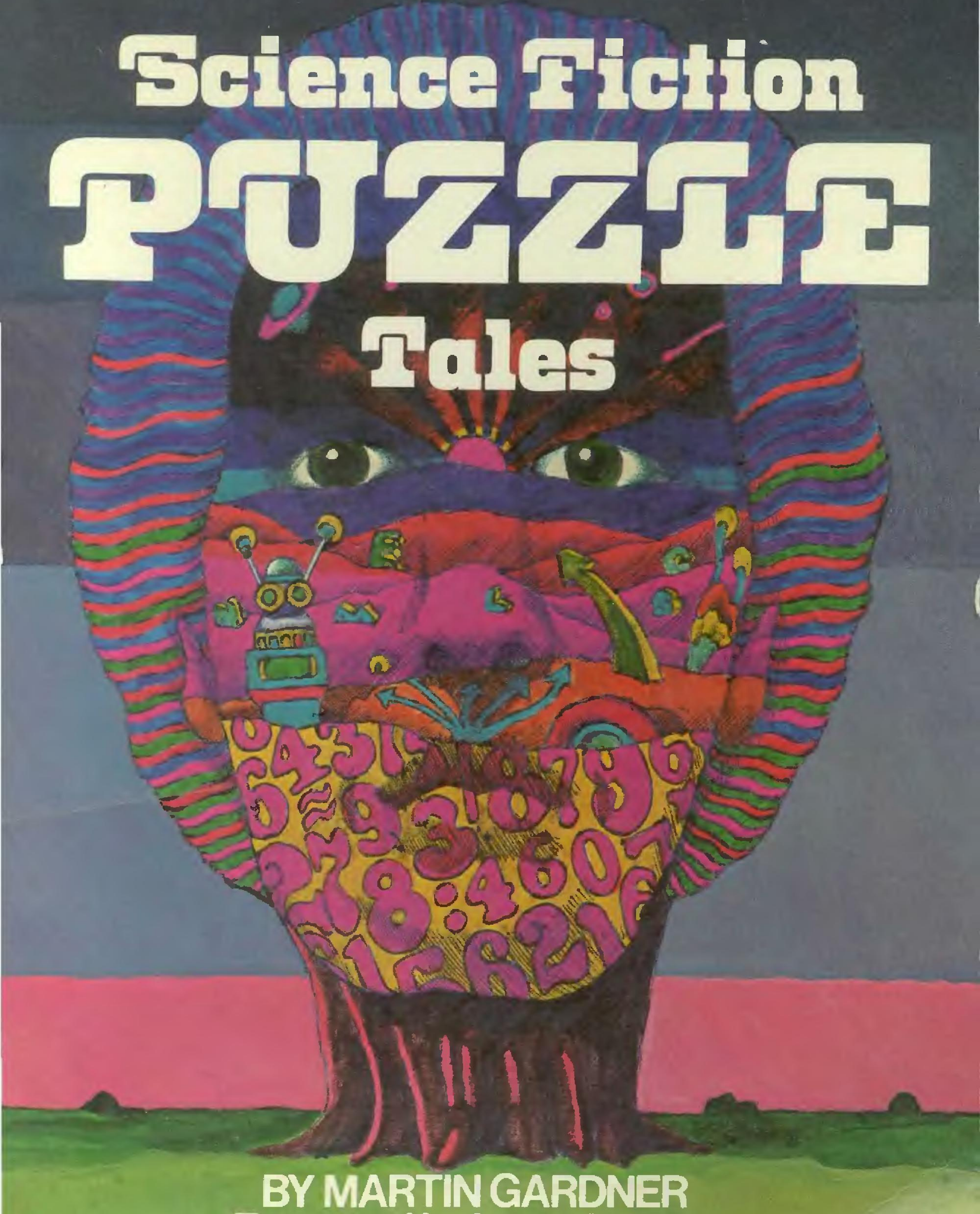
Science Fiction PUZZLE Tales



BY MARTIN GARDNER
Foreword by Isaac Asimov

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FOREWORD BY ISAAC ASIMOV

CLARKSON N. POTTER, INC./PUBLISHERS, NEW YORK
Distributed by Crown Publishers, Inc.

For Isaac Asimov,
of course

Inquiries should be addressed to Clarkson N. Potter, Inc., One Park Avenue, New York, New York 10016

Printed in the United States of America

Published simultaneously in Canada by General Publishing Company Limited

Library of Congress Cataloging in Publication Data

Gardner, Martin, 1914–
Science fiction puzzle tales.
Bibliography: p.
1. Puzzles. 2. Science fiction—Miscellanea.
I. Title.
GV1507.G35 1981 793.73 80-25536
ISBN: 0-517-54380X (cloth)
0-517-543818 (paper)

10 9 8 7 6 5 4 3 2 1

FIRST EDITION

DESIGNED BY BETTY BINNS GRAPHICS

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ANSWERS

FOREWORD

In my lengthening life, I have been fortunate enough to meet a number of rational men—not a large number, to be sure, but enough. One rational man makes up for thousands of fuzzy thinkers when it comes to companionship.

Of all those I have met, Martin Gardner is the quietest and least impassioned about it, but very effective just the same. Back in the 1950s, he wrote his classic *Fads and Fallacies in the Name of Science*, and there has never been a harder blow at science's irrational fringe. The quietness of Martin's style made it difficult for anyone to inveigh against the book, and its rigid rationality deprived them, in any case, of any sensible grounds for doing so.

Most people who encounter Martin these days do so in the pages of *Scientific American*, where, for a quarter of a century, he has composed a monthly column called "Mathematical Games," and done so with remarkable insouciance and charm.

So delightful is his approach, that on many occasions I have found myself reading the column with pleasure, though some of its details have managed to get past me. Even when you can't quite see the details of the corner of mathematics that Martin spreads out before you, the grand design is unfailingly fascinating.

It might be supposed that one should sneer a bit at anything called "recreational mathematics" or "mathematical games." Are such things not just "recreations"? Just "games"? They can't be of any importance, one might think. They're just a way of fooling around.

Who really cares how many ways you can pair up people at a bridge table, or how many colors are needed to fill up a map under certain conditions, or how many routes a knight can take about a chessboard, or what the shortest path from one city to another might be if you follow a particular type of route?

But mathematicians do care and always have.

It might be argued, in fact, that all mathematics begins as "Games" in the sense that the first glimmerings of any part of it seem to have no use.

There must have been a time when some prehistoric genius said to a friend, "See here. Suppose I have two stone knives. I can make two piles out of them, both with the same number. If I add another knife, I can't divide them equally. If I add still another knife, I can. And if I add yet another knife, I can't. Do you suppose this sort of thing goes on forever?"

Undoubtedly, the friend said, in honest astonishment, "Who cares? Why are you sitting there dividing knives into heaps? Use one of them to kill something. Do something practical!"

Also, undoubtedly, the primitive mathematician found it wonderful to continue to pass the time considering this question of equal piles and to wonder further if there were any system to the matter of making three equal piles and so on.

It was just a game; it had no practical use. Eventually, though, such questions of divisibility—of the behavior of heaps when combined or divided into unequal heaps, or into arrays—came to be generalized into systems of computation that made it possible to add, subtract, multiply, and divide.

Imagine the excitement when a government official discovered for the first time that such computations would make it far easier to collect taxes and keep track of expenditures. At once the game stopped being a game and became a hard-nosed business, very suitable for "practical" men.

There will always be a tendency, however, for mathematicians to move away from those branches of the field that are too readily applied to the daily business of life. Unquestionably, there is more fun in fiddling around with problems when no one is glancing over one's shoulder and saying, "Have you got it worked out yet? We desperately need it to turn a profit this quarter."

Yet it is so hard to keep the games recreational. Many a time mathematicians have been convinced they had some kind of problem that couldn't be of use to anybody, something so massively unimportant that no one could conceivably want to interfere with the mathematical pleasure of such nonsense. Then someone comes along and finds that this "nonsense" can be used to make possible intricate telephone-switching capabilities or to explain the behavior of arcane subatomic particles. Mathematicians must then find another refuge.

Well, Martin offers everybody (not just mathematicians) creative refuge for the imagination. The puzzles in this book are not just puzzles. Very often, they embody deep mathematical principles that deal with matters not yet well enough understood to be applied to the practical world. Such "games" are *not* more trivial than "real" mathematics. They may well be more important and may be the foreshadowing of future mathematics.

The puzzles that follow are woven into short science fiction stories. They add amusement but are not the essence of the book. The science fiction is important, though, because it demonstrates that however times, customs, and technologies alter, the essence of mathematical relationships is, was, and will be the same. It is probably the only truly rigid and relentlessly constant factor in an otherwise ever-changing universe.

Isaac Asimov
January 1981

PREFACE

When Isaac Asimov and George Scithers began planning *Isaac Asimov's Science Fiction Magazine* (henceforth, *IASFM*) in 1976, George approached me at a gathering of the Trap Door Spiders, a curious club to which the three of us belong, to suggest a puzzle feature. Was it possible, he asked, to weave a puzzle into some sort of science fiction vignette or pastiche? In other words, present the puzzle with a SF story line. If so, would I be interested in doing this as a regular feature for the new magazine?

The idea was intriguing, especially since I had once perpetrated two SF stories based on topological curiosities: "The No-Sided Professor" and "The Island of Five Colors." I cleaned up an off-color combinatorial problem, never before published, for my contribution to Volume 1, Number 1, dated Spring 1977, and have been writing the puzzles ever since. I enjoy writing them and I know from letters that readers like to work on them.

This book brings together the first thirty-six *IASFM* puzzles. To almost all of them I have added a postscript, which allows me to explain some (not all) of my compulsive wordplay, to thank whoever should be thanked, to discuss feedback from readers, and to suggest books and articles containing interesting material relating to the puzzles.

Good puzzles are usually jumping-off points for serious mathematics. You'd be surprised how much math you can learn by exploring some of the implications and ramifications of what may seem at first no more than a trivial brainteaser.

HOW TO USE THIS BOOK

There is always a strong temptation, when answers are given in a book of puzzles, not to spend much time trying to solve a puzzle. It's too easy to turn to the answer!

To get the most fun and instruction out of this book, let me urge you to work on every problem before you give up and check its answer. Each story-puzzle is numbered; the solution (or solutions), similarly numbered, will be found in the First Answers section. In most cases a new problem, related to the original, is posed at the end of the answer. These are solved in the Second Answers section. In some cases there is then a third question at the end of the second answer that leads to still another solution in the Third Answers section.

At the end of almost every final answer you will find a postscript in which there are additional comments concerning the preceding questions. Occasionally I mention books and articles of special interest that will tell you more about the topics under discussion.

To make for easier reading, only the titles of books are given. These books, including my own, are listed alphabetically by author, with publisher and date of the most readily accessible edition, in the bibliography at the back of the book. Periodicals and journals receive full citations in the text.

PUZZLES

PUZZLE 1

LOST ON CAPRA

Dr. Ziege, the eminent German extraterrestrial geologist, was the first human to set foot on Capra, the fifth planet from the star Capella. For several months she and her two companions explored the planet by spacecar.

Capra is roughly twice the size of the earth, but lacking in enough water to support life. Dr. Ziege found the planet a barren, sandy waste, its surface as smooth as the plains of Kansas. Like the earth, Capra rotates on an axis. Dr. Ziege designated one pole north and the other south in conformity with the ship's magnetic compass and the planet's earthlike magnetic field. Geographic and magnetic Caprian poles coincide.

The last radio message from Dr. Ziege was: "We have lost our bearings and cannot find the spaceship. Yesterday we drove 10 myriameters due south from our last camp site, then 10 myriameters due east, then 10 myriameters due north. We find ourselves back at the camp site. Food supplies exhausted. Send help."

Attempts to reach Dr. Ziege for precise information as to her location brought no response. The German government immediately fired a rescue ship through Wheeler wormhole 124C41+. Two days later it was circling Capra with plans to land near the north pole. It seemed obvious that only from that pole could Dr. Ziege and her men go 10 myriameters south, then east, then north and be back at the starting spot. But there were no signs of the explorers within a radius of 20 myriameters from the north pole.

"Ach!" shouted Felix, striking his temples. "We are looking in the wrong place. *Another* spot fits Dr. Ziege's message perfectly."

"How can that be?" said Hilda. "If the starting spot is a few kilometers from the north pole, the terminal spot will miss the pole by a short distance. The farther south you go, the more it misses. At the equator it misses the starting spot by a full ten myriameters. And south of the equator it will miss by more than that!"

Nevertheless Felix was right. Where should they look next?

PUZZLE 2

THE DOCTORS' DILEMMA

The first earth colony on Mars has been swept by an epidemic of Barsoomian flu. The cause: a native Martian virus not yet isolated.

There is no way to identify a newly infected person until the symptoms appear weeks later. The flu is highly contagious, but only by direct contact. The virus transfers readily from flesh to flesh, or from flesh to any object which in turn can contaminate any flesh it touches. Residents are going to extreme lengths to avoid touching one another, or touching objects that may be contaminated.

Ms. Hooker, director of the colony, has been seriously injured in a rocket accident. Three immediate operations are required. The first will be performed by Dr. Xenophon, the second by Dr. Ypsilanti, the third by Dr. Zeno. Any of the surgeons may be infected with Barsoomian flu. Ms. Hooker, too, may have caught the disease.

Just before the first operation it is discovered that the colony's hospital has only two pairs of sterile surgeon's gloves. No others are obtainable and there is no time for resterilizing. Each surgeon must operate with both hands.

"I don't see how we can avoid the risk of one of us becoming infected," says Dr. Xenophon to Dr. Zeno. "When I operate, my hands may contaminate the insides of my gloves. Ms. Hooker's body may contaminate the outsides. The same thing will happen to the gloves worn by Dr. Ypsilanti. When it's your turn, you'll have to wear gloves that could be contaminated on both sides."

"*Au contraire*," says Dr. Zeno, who had taken a course in topology when he was a young medical student in Paris. "There's a simple procedure that will eliminate all risk of any of us catching the flu from one another or from Ms. Hooker."

What does Dr. Zeno have in mind?

3

PUZZLE

SPACE POOL

Two young physicists were discussing their vacation plans.

"I may take a space cruise," said Jones. "I've been told that the food and the girls on the *Cutty Snark* are superb, and that this summer the cruise includes landings on the moon, Mars, and Venus."

"I went last year," said Smith, "and had a marvelous time. The ship has a huge recreation room with all sorts of new games. Space pool, for instance. When the ship's in a g-field it's played the regular way, only the table is enormous and there are more than 100 balls."

"How is it played in zero gravity?"

"Some engineer figured out a way to create a green-tinted magnetic force field," said Smith. "It keeps the balls inside a rectangular parallelepiped about a meter above the table. The ivory balls have iron cores. They bounce off the green walls the same way they bounce off the cushions on the table. The wooden cues are not affected by the field, so you can poke them into the field at any spot. The pockets are holes in the field's eight corners. If a ball hits a corner it leaves the field and you score the ball's number like in ordinary pool."

"But won't the balls keep on moving after they're hit? How can you stroke the cue ball when it's on the wing?"

"The balls freeze exactly ten seconds after each stroke," said Smith. "I don't know how it works. I think another force field brings all the balls to a dead stop."

"How many balls are there?"

"I can't recall. Somewhere between one and two hundred. When the game's played on the table it starts with the balls packed into a triangle like the 15 balls of regular pool. When it's played in space you start with the same set of balls packed into a regular tetrahedron."

"In other words," said Jones, "the number of balls is both triangular and tetrahedral. There can't be many numbers like that."

Smith closed his eyes. "Well, there's 1. It's triangular and tetrahedral, but that's trivial. The next tetrahedron is a triangle of 3 balls with 1 ball on top, or 4 altogether. But 4 balls won't make a triangle."

"Ten will," said Jones. "It makes a triangle with rows of 1, 2, 3, and 4. And it also makes a tetrahedron. Every tetrahedral number is the sum of consecutive triangles; and triangles 1, 3, and 6 add to 10."

Jones took out his calculator. "Let's see. If I remember my number theory, triangular numbers have the form $\frac{1}{2}\, n(n + 1)$ where n is any positive integer. Tetrahedral numbers have the form $\frac{1}{6}\, n(n + 1)\,(n + 2)$."

It didn't take Jones long to discover that the third number to fit both formulas was between 100 and 200. He could find no other solution less than 200, so this was the number he wanted.

With the aid of a pocket calculator, how quickly can you determine the number of balls (not counting the cue ball) used in space pool?

4

MACHISMO ON BYRONIA

PUZZLE

Byronia, a small planet that orbits a sun near ours, has a humanoid population similar to our own. The most striking difference is that Byronians come in three sexes. They correspond roughly to what we call male, female, and bisexual.

Because bisexuals have both male and female organs, they can perform as either sex and also bear children. Whenever a "mother" (female or bisexual) gives birth, the probability that the child is male, female, or bisexual is exactly one-third for each.

The new Supreme Ruler of Byronia, Norman Machismo, is a virile, hot-tempered male who gained total power by defeating a rebellious army of bisexuals. To solve the "bisexual problem" Machismo has issued the following decree: Every mother on Byronia, as soon as she or it gives birth to a bisexual, is to be rendered incapable of further conception.

Machismo reasoned like this. Some mothers are sure to have two, three, four, or even more heterosexuals before having a bisexual. True, occasionally a mother will have a bisexual first child, but that will be the end of her childbearing, so these births will contribute only a small percentage of bisexuals to the population. In this way the proportion of bisexuals in the population will steadily diminish.

Will the Supreme Ruler's plan work?

PUZZLE 5

THE DEFECTIVE DOYLES

Shurl and Watts, at a base on Pluto, are in charge of distributing doyles to more distant outposts. Doyles are the size of peas, all identical, each weighing precisely 1 gram. They are indispensable in hyperspace propulsion systems.

Doyles come in cans of 100 doyles each, and shipments are made up of six cans at a time. The Pluto base has a sensitive spring scale capable of registering fractions of milligrams.

One day, a week after a shipment of doyles, a radio message came from the manufacturing company in Hong Kong. "Urgent. One can is filled with defective doyles, each with an excess weight of 1 milligram. Identify can and destroy its doyles at once."

"I suppose," said Watts, "we'll have to make six weighings, one doyle from each can."

"Not so, my dear Watts," said Shurl. "We can identify the can of defectives with just one weighing. First we number the cans from one through six. Then we take 1 doyle from the first can, 2 from the second can, 3 from the third, and so on to 6 from the sixth can. We place this set of 21 doyles on the scale. It will weigh *n* milligrams over 21 grams, and of course *n* will be the number of the defective can."

"How absurdly simple!" exclaimed Watts, while Shurl shrugged.

A month later, after the next shipment, another message arrived: "Any of the six cans, perhaps all of them, may be full of defective doyles, each 1 milligram overweight. Identify and destroy all defective doyles."

"This time," said Watts, "I suppose we'll have to weigh separately a doyle from each can."

Shurl put his fingertips together and gazed at a picture of Isaac Asimov on the wall. "A capital problem, Watts. No, I think we can still do it in just one weighing."

What algorithm does Shurl have in mind?

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THE THIRD DR. MOREAU

PUZZLE

It is not widely known among science fiction buffs that Dr. Moreau, about whom H. G. Wells wrote his famous SF novella, had a grandson who calls himself Dr. Moreau III. Dr. Moreau III is a professor of genetics at King's College, in London, where he is considered one of the world's top researchers in genetic engineering.

By tinkering with a microbe's DNA helix, Dr. Moreau III recently managed to produce a strange new type of one-celled organism which he calls *Septolis quarkolis*. Drawing nourishment from the air and using energy derived from quarks, the new microbe splits every hour into seven replicas of itself. Each replica instantly becomes the same size as the original. Thus after 1 hour a single microbe becomes 7, after another hour the 7 become 49, in another hour the 49 become 343, and so on. As Dr. Moreau put it, in his report in *Nature*, *Septolis quarkolis* "multiplies at an alarming rate."

One day Dr. Moreau III put a single microbe, just "born," into a large and empty glass container. Fifty hours later the container was completely filled. Dr. Moreau then quickly destroyed all the microbes by bombarding them with tachyons. Otherwise, in a few more days they would have engulfed all of King's College.

I happened to be visiting King's College a few days after this event. Always alert for puzzle possibilities, I asked Dr. Moreau III's assistant, a chimpanzee named Montgomery, when the glass container was exactly 1/7 full of the microbes. Montgomery whipped out his pocket calculator and started working on the problem, but an hour later he still didn't have the answer. It was, he told me, beyond the capacity of his computer's readout.

Can the reader determine how many hours elapsed until the container was 1/7 full?