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ROMBIX™

ILLUSTRATED BOOKLET

THE BACKGROUND OF ROMBIX

Rombix is for people who enjoy taking things apart and putting them back together again, not necessarily the same way each time. When I invented Rombix, I was trying to squeeze into the circle properties of two quite different puzzles I had learned about by reading Martin Gardner's famous columns on Mathematical Games and Recreations in *Scientific American* magazine. One of these puzzles is the popular family of 'polyominoes' popularized in the fifties by my friend Solomon Golomb; the other is the revolutionary set of tiles invented in the seventies by Roger Penrose.

As soon as I had constructed the first set of Rombix, I began to discover — little by little — that Rombix has many distinctive properties of its own. One of these is that it can be enjoyed at many different levels of understanding. Young children can master any of the simpler challenges offered by a Rombix set. On the other hand, there are a few properties of Rombix which can be appreciated in depth only by a person with some mathematical training. Paradoxically, however, those same properties are the basis of simple puzzle activities which can be enjoyed even by a young child. I wish to acknowledge that Kate Jones suggested the Rombix game "Double Touch".

There are actually *infinitely many* different versions of Rombix — one for every positive integer. However, Rombix quickly becomes very difficult when that integer is a little larger than eight. Your Rombix set is the one for the integer eight. Some puzzle diehards may want to construct more complicated versions for themselves. I encourage them to do so! (They should be able to figure out how to do it by carefully examining the shapes of the pieces in this set.)

In this pamphlet, I've summarized some things you're likely to want to know about Rombix. I've left out a few interesting things, so that you can discover them for yourself. I'm sure that you will also find properties of Rombix that nobody else yet knows about.

Alan Schoen

What is ROMBIX?

It is a set of 16 pieces called *Rombiks* — no two alike — which fit together to tile a regular 16-sided polygon (the *Arena*). Any such arrangement is called a *Circle Tiling*. The Rombiks can be arranged in a great variety of ways.

If you have more than one Rombix set, you can play the game 'Loose Ends', which is described below. You can also try the puzzle challenges which are explained at the end of this booklet.

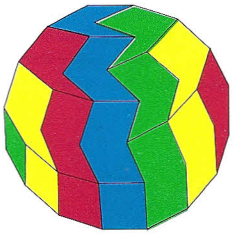
The 16 Rombiks consist of:

(a) four single rhombs (*Keystones*) and

(b) every possible concave pair (*Twin*) which can be formed by joining two Keystones.

When the two rhombs in a Twin are of the same shape, the Twin is called *Identical* — otherwise, it is called *Fraternal*.

A unique orderly Circle Tiling is the *Cracked Egg*, which is shown here (this is the way the pieces came in the package).



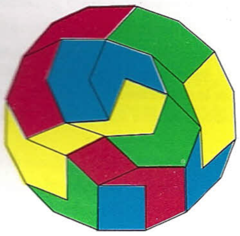
Cracked Egg

Each of the four colored subsets of Rombiks contains exactly the same inventory of basic rhombic units.

Do you like challenges?

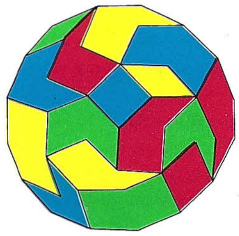
In order of difficulty — from lesser to greater — try the following:

•*Chaotic Colors.* Tile the Circle in any pattern whatsoever. (Less than 1 minute: Master ROM; less than 10 minutes: Senior ROM; less than 1 hour: Junior ROM; more than 1 hour, NeoROM.)



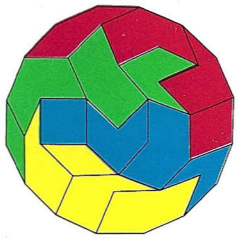
Chaotic Colors

•*Completely Scattered Colors.* Make a Circle Tiling in which no two Rombiks of the same color touch along an edge. (Less than 1 hour: MasterROM; less than 2 hours: Senior ROM; less than 5 hours: Junior ROM. NeoROMS may not be able to do it at all!)



Completely Scattered Colors

•*Completely Collected Colors.* Tile the Circle with each colored subset isolated from the other three. (Level of difficulty: harder than the Scattered Tiling.)



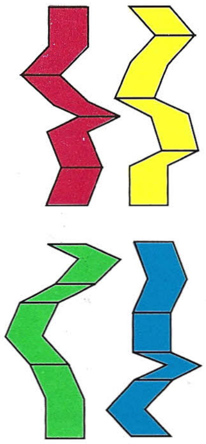
Completely Collected Colors

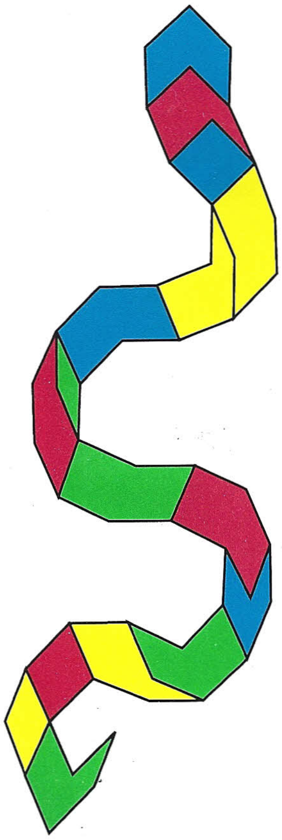
LADDERS — Special Rombik subsets

A *Ladder* is a chain of rhombs or Rombiks which extends from one boundary edge of a Circle Tiling to the diametrically opposite boundary edge. All of the rhombs in a ladder meet pairwise along edges called *rungs*, which are parallel to the boundary edges. The edges of the end rhombs of the ladder, which lie on the boundary, are the *terminal* rungs.

In every ladder in a Circle Tiling, there is one square and two of each of the remaining three rhombs — one leaning to the left, and the other to the right. Each of the four colored subsets is made up of exactly the Rombiks required to form a ladder. Three of the subsets can form ninety-six different ladders each; the fourth can form forty-eight. (If we allow mixed-color ladders, we can make 1272 different ladders!)

The four colored subsets can be paired in six different ways. How many of these six pairs can form a ladder of the same shape? It is fundamentally impossible for more than two colored subsets to form a ladder of the same shape. *Why?*



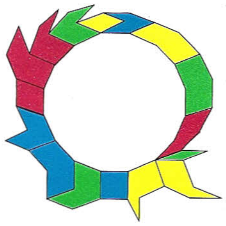


SNAKE

OTHER ROMBIX PUZZLE CHALLENGES

• French's Fences

Arrange the sixteen Rombiks in an 'inside out' pattern to a make a *fence* which encloses as large an area as possible. The Rombiks must fit edge-to-edge in the usual way, and the fence cannot be of zero width anywhere. (The example shown at the right does *not* enclose the largest possible area!)



• Wallpaper patterns

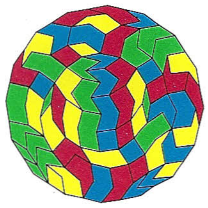
Design an *infinite repeating pattern*—just like wallpaper—using all sixteen Rombiks for the pattern motif. Try to make the perimeter of the pattern motif *as short as possible.* (How short can it be?)

• Centro-symmetric Patterns (more than one set)

Arrange the Rombiks in a pattern which has a single center and which radiates outward in all directions. Design it so that it has either two, four, eight, or sixteen angular sectors, each tiled in the same pattern.

• Eccentric Rings

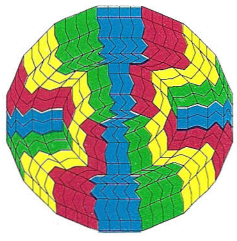
Here's an example of an *Eccentric Ring.* The central core of the pattern is a single-set Circle Tiling. The Ring itself is tiled by *three* sets.



There are eleven other shapes for such rings, but this one is the most nearly *concentric* of all twelve.

Can you tile every one of the twelve Eccentric Ring shapes with three Rombix sets?

• Concentric Rings



Concentric Rings tiled by 12, 20,28,36, ... ROMBIX sets, respectively, can be arranged in nested fashion around a central nucleus of four ROMBIX sets. The nucleus is shown here as an *Expanded Cracked Egg*. The Rings can be tiled in either orderly or chaotic fashion.

Concentric Rings tiled by 8, 16, 24, 32, ... ROMBIX sets, respectively, can be nested around a nucleus which is a 1-set Circle Tiling. These Rings can also be tiled in either orderly or chaotic fashion.

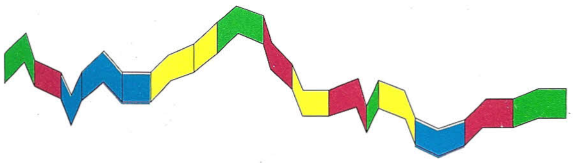
• Matching Shapes

Can you discover a shape which can be tiled by every one of the four colored subsets?

(*If you can't do it with four, try three!*)

• Super Ribbons

There are 351,026,165,273,591,808,000 different *Super Ribbons* you can make by joining all sixteen Rombiks edge-to-edge in a strip like this:



If you and everyone else in the world were to design a Super Ribbon as a personal 'signature', the odds are about 50 billion to one that nobody else would make one just like yours.

• RomFont (Alphabet)

Here's a font of lower-case Roman letters tiled by Rombiks. (Can you design a complete set of *capital letters?*)

OVALS

There are thirty Ovals, all of which can be tiled by Rombiks. The largest Oval is the outline of the Cracked Egg Circle Tiling. It's called No.8-1, because it has 8 x 2 = 16 sides, and it's the number 1 (and only) 16-sided Oval. It contains 28 (= (8 x 7) / 2) rhombs.

Here's an elegant way to makle a sequence of smaller and smaller Ovals: First remove the longest ribbon of Rombiks (blue) from the middle of the Cracked Egg Circle Tiling, and then join the separated halves of the tiling to make a smaller Oval. It's is called No.7-1 because it has 7 x 2 = 14 sides and is the only 14-sided Oval. It contains 21 (= (7 x 6) / 2) rhombs.

Next remove the longest ribbon (green) from the middle of Oval No.7-1. You'll then obtain No.6-1, which is one of four 12-sided Ovals. It contains 15 (= (6 x 5) / 2) rhombs.

Continue removing the longest ribbon from each newly formed Oval (red, yellow, yellow, red, and green ribbons), obtaining— altogether —

No.8-1	16 sides	28 rhombs	1 only
No.7-1	14 sides	21 rhombs	1 only
No.6-1	12 sides	15 rhombs	1 of 4
No.5-1	10 sides	10 rhombs	1 of 5
No.4-1	8 sides	6 rhombs	1 of 8
No.3-1	6 sides	3 rhombs	1 of 5
No.2-1	4 sides	1 rhombs	1 of 4
No.1-1	2 sides	0 rhombs	1 only
No.0-0	0 sides	0 rhombs	1 only

Curiously,

OVALS ALWAYS COME IN *MATCHED PAIRS* :

No.0-1 and No.8-1,
No.1-1 and No.7-1,
Nos.2-1 through 2-5 and Nos.6-1 through 6-5, respectively
(etc.)

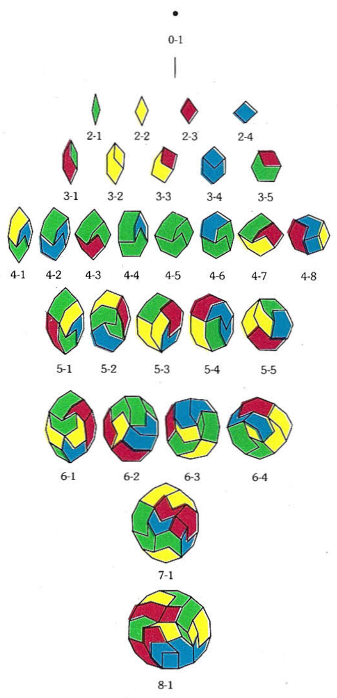
The area of the larger Oval in each pair always exceeds that of the smaller one by *a whole number of colored subsets.*

If you combine No.0-1 with *four* colored subsets, you can make No.8-1.

If you combine No.1-1 with *three* colored subsets, you can make No.7-1.

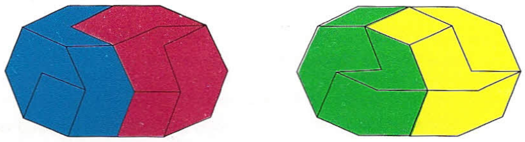
If you combine Nos.2-1 through 2-4 (the *Keystones*) with *two* colored subsets, you can make Nos.6-1 through 6-4, respectively.

If you combine the Rombiks of Nos.3-1 through 3-5 with *one* colored subset, you can make Nos.5-1 through 5-5, respectively.



STRETCHED OVALS

A ***stretched Oval*** is an Oval which has one or more pairs of opposite sides which are at least *twice* as long as the edge of a Rombik.



How many Stretched Ovals can be tiled by some or all of the Rombiks of one set? Of two sets?

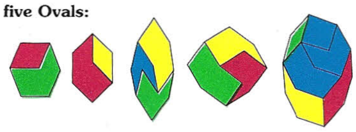
PARTITIONS INTO OVALS

An ***Oval Partition*** is a set of three or more Ovals which are tiled by the sixteen Rombiks.

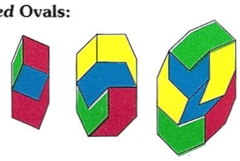
There are more than one hundred different Oval Partitions, and there are twelve different *families* of partitions. A family is defined by how many Ovals there are in the partition, and also by how many rhombs are contained in each Oval.

The Rombiks can be partitioned among three, four, five, six, seven, or eight Ovals— *but not two!* (Can you explain why two is ruled out?)

Here's a partition into five Ovals:

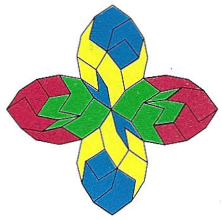


And here's a partition into three *Stretched* Ovals:



CHIPPED OVALS AND FLOWERS

A ***Chipped Oval*** is an Oval from which a single rhomb which lies somewhere along the boundary has been removed. The most interesting case is a 12-sided Oval (15 rhombs) from which a boundary rhomb has been removed, leaving 14 rhombs. That's just the right number of rhombs for tilings by ***two colored subsets***, because each colored subset contains 7 rhombs.



Using your two Rombix sets (32 Rombiks), you can make many symmetrical patterns based on Chipped Ovals. One of them resembles a 4-leaf clover (shown above), and the other looks like a flower with eight petals (You can discover that one for yourself!).

How many different shapes of Chipped Ovals can you make?

You can join together as many as thirty-two Chipped Ovals in a circular ring pattern, but then you'll need more than a thousand Rombiks to tile the hole in the ring! For some rings, the hole cannot be tiled all the way to the center of the pattern.

The Chipped Ovals in some rings may even be of two different shapes, in an alternating sequence.

POLKA DOTS

Suppose you want to cover a vast flat area with Rombix Circle Tilings arranged like the dots in a polka dot pattern.

1. All of the spaces *between* the dots must be tiled by Rombiks.

2. No two edges of rhombs which meet at a point can lie on the same straight line.

HOW CLOSE TOGETHER CAN YOU ARRANGE THE DOTS ?