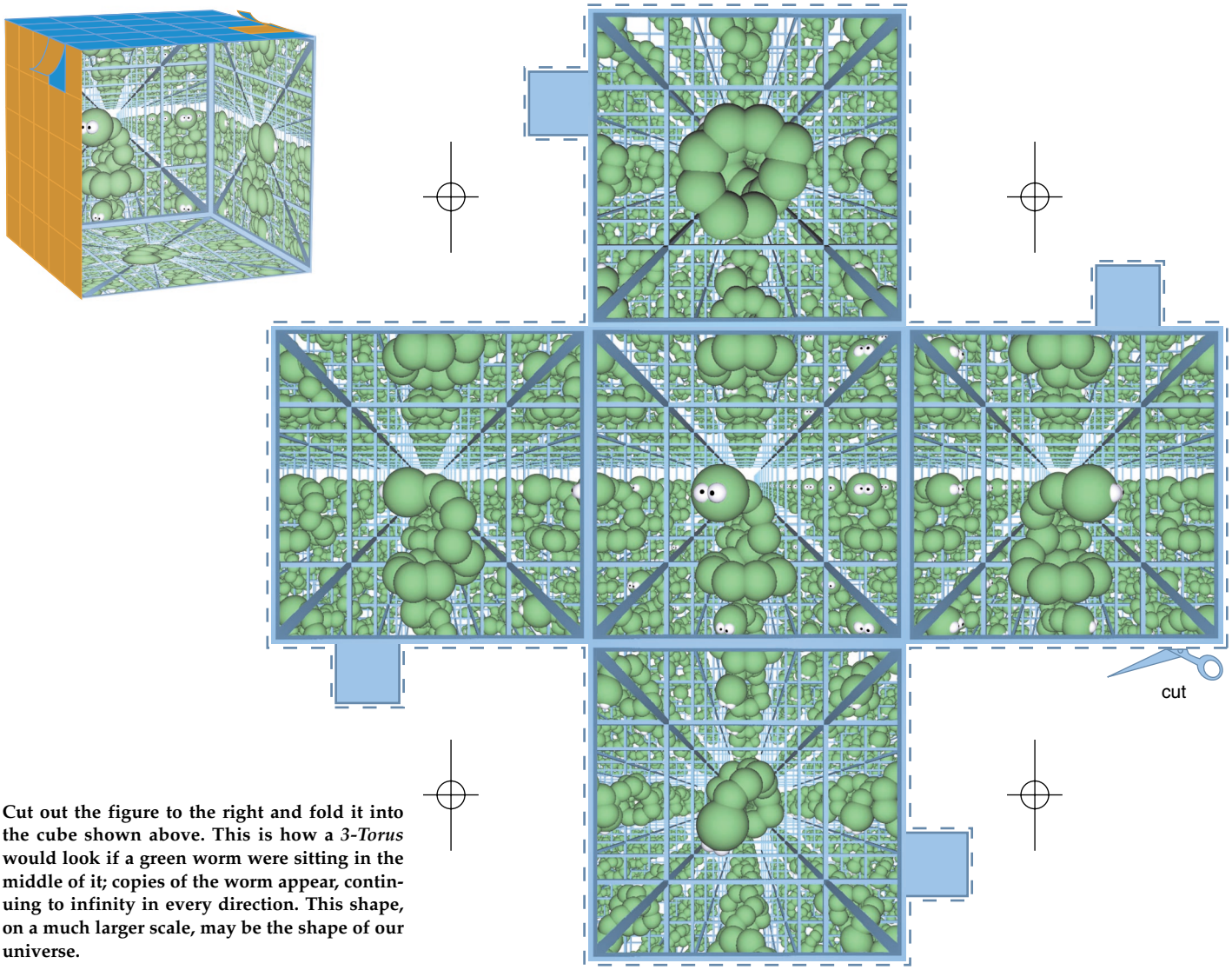


Cut out the figure to the right and fold it into the cube shown above. This is how a *3-Torus* would look if a green worm were sitting in the middle of it; copies of the worm appear, continuing to infinity in every direction. This shape, on a much larger scale, may be the shape of our universe.

The Shape of the Universe: One Possibility

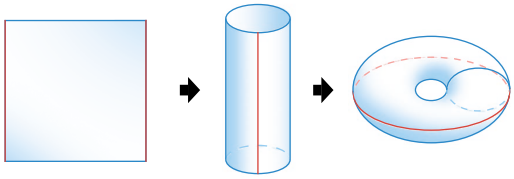
Web insert for Colin Adams's and Joey Lawrence's The Shape of the Universe: Ten Possibilities, *American Scientist September–October 2001*

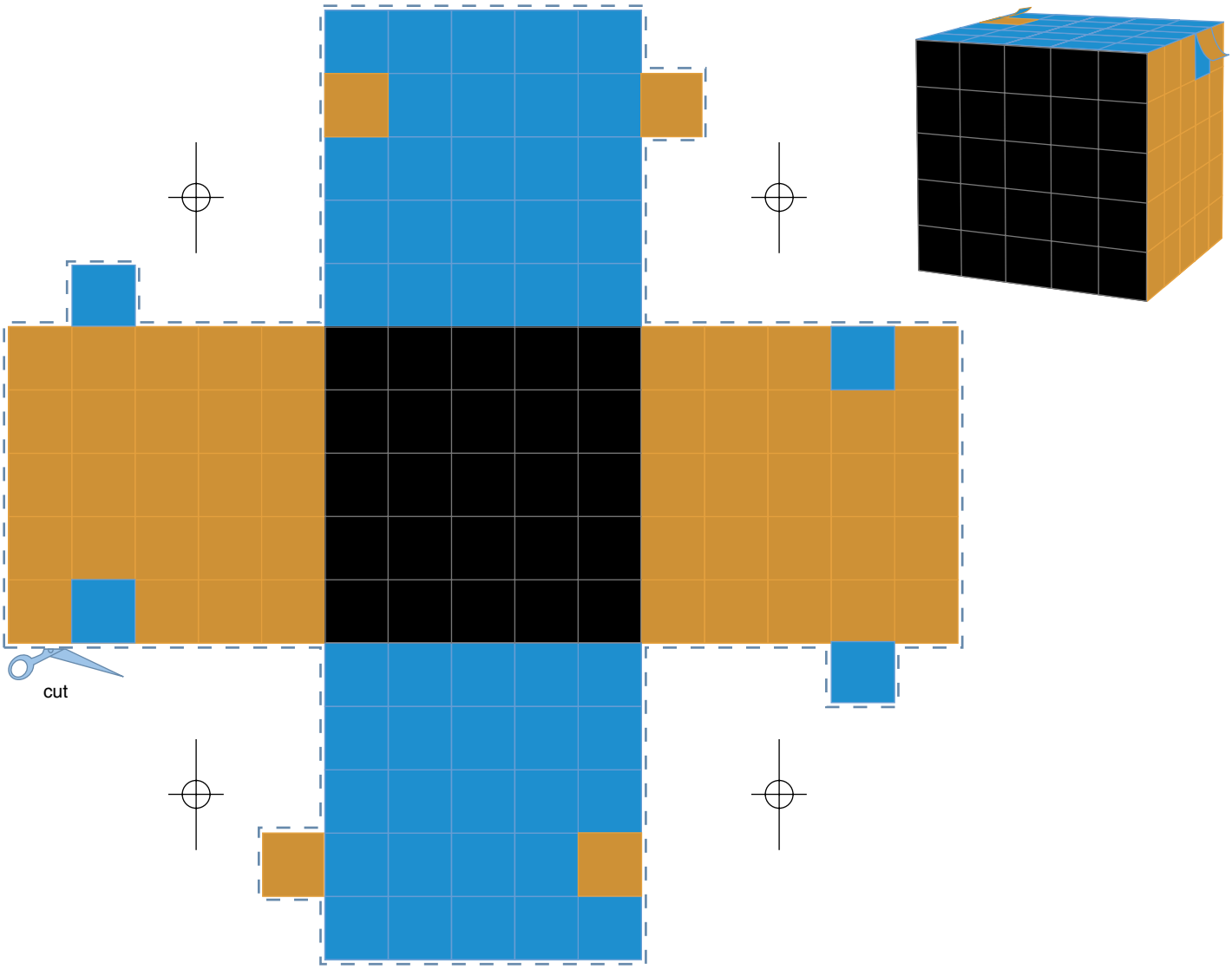
We understand much about our planet, our galaxy and our universe. But a fundamental mystery remains. What is the topological shape of the universe?

Recent observations in astronomy are beginning to limit the wide range of possibilities. One type of shape, called a Euclidean 3-manifold, has arisen as a prime candidate. Amazingly, there are only 18 Euclidean 3-manifolds and, of these, only ten are probable candidates for the universe. One of these, the 3-Torus, is the focus of this insert.

One way to picture a 2-dimensional torus is to start with a square. Pretend the square is a piece of paper, and construct a cylinder by gluing the left side of the square to the right side. The top and bottom sides of the paper have become the circles on the top and bottom of the cylinder. Gluing those two circles together creates a torus (*see below*).

The 3-torus is the generalization of the torus in a higher dimension. Instead of gluing together the opposite edges of a square, the opposite faces of a cube are joined. In the 3-torus, every point on a face of the cube is glued to the corresponding





point at exactly the same spot on the opposite face. On the diagram to the right the blue face is glued to the other blue face, orange to orange, and front to back. For illustrative purposes, worms traveling through the glued faces demonstrate the absence of rotation between the faces.

If you, or a green worm, were somehow in this 3-manifold and looked forward, you would see the back of your own head. You would see copies of yourself in each face of the cube: forward, backward, left, right, above and below. Past these copies, other copies would be visible—copies as far as the eye could see. Standing in a 3-torus and looking out is similar to standing in a fun-house room of mirrors. But in the 3-torus, the images are never reversed. Cut, fold and glue the figure on the top half of this page to better understand what standing in a 3-torus would feel like.