THANKS TO PROFESSOR KAY SMITH, ST. OLAF STUDENTS HAVE BECOME MORE AWARE OF THE

MATHEMATICAL SYMMETRY

THAT EXISTS ALL OVER CAMPUS.

BY MARA KUMAGAI FINK '11 · PHOTOGRAPHS BY TOM ROSTER

WHEN KAY SMITH WALKS ACROSS CAMPUS, she sees more than just the limestone walls of Holland and Mellby halls and Boe Memorial Chapel. She sees geometrical shapes, patterns, and symmetry in everything, from the exterior of Dittmann Center to the facades of Old Main and the Speech-Theater Building and even the ceiling of Rølvaag Library.

"Being a mathematician influences the way I view the world," says Smith, an associate professor of mathematics at St. Olaf. "Since mathematicians study form and structure, I am accustomed to looking for patterns and analyzing them."

Thanks to her penchant for patterns, St. Olaf mathematics students have become more aware of the beautiful art and symmetry that exists in buildings all over campus. Smith has incorporated a unique project into her classes that requires students to look for patterns in St. Olaf structures and report on their findings.

The decoration around the top of Steensland Hall is a strip pattern with a vertical axis of reflection.

"I want students to appreciate that mathematics provides a way of looking at, describing, and better understanding their world," she says. "And in addition to the mathematical lesson, I hope they also appreciate the craftsmanship that went into the construction of the older buildings on campus."

SYMMETRIC PATTERNS

"MATHEMATICIANS classify figures or patterns based on the types of symmetry they exhibit," says Smith.

In everyday usage, symmetry usually refers to *reflection* symmetry, she explains. One half of an object is the mirror image of the other. The line dividing the two halves is called the *axis of reflection.*

"For example, a square has four axes of reflection: a horizontal line that cuts the two sides in half, a vertical line that bisects the top and bottom, and the two diagonals that connect opposite corners of the square," Smith says. "A square also has *rotation* symmetry; it looks exactly the same even after it has been rotated 90°, 180°, or 270° around the point where its diagonals cross.

"For another example, consider the alphabet. The letters C and D have reflection symmetry," she says. "The axis of reflection is horizontal. The letters N and Z have rotation symmetry; they rotate 180° around the midpoint of the diagonal line. The letter H has both rotation and reflection symmetry. Strip and wallpaper patterns may also have reflection, rotation, or glide reflection symmetry. A *glide reflection* consists of a translation followed by a reflection."

Smith says some designs are produced by repeating a motif. Repetition in exactly one direction creates a *strip pattern*, like a wallpaper border, while repetition in more than one direction creates *wallpaper patterns*. To analyze the symmetries of these designs, mathematicians consider the pattern that would result if the motif repeated indefinitely. Strip and wallpaper patterns always have *translation* symmetry — the pattern can be shifted and not look like it has changed.

On the following pages are examples of various types of mathematical symmetry that have been found by students on the St. Olaf campus. [CONTINUED]


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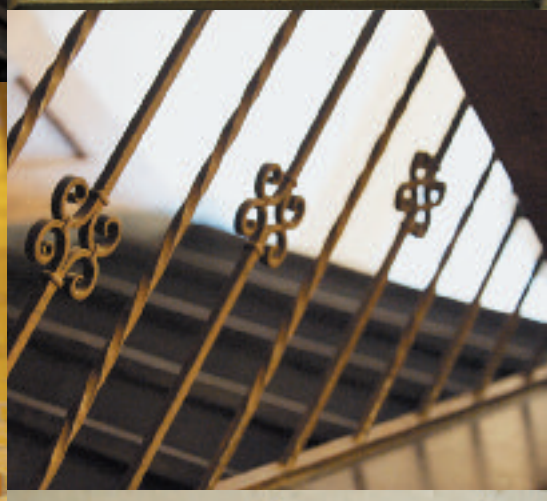
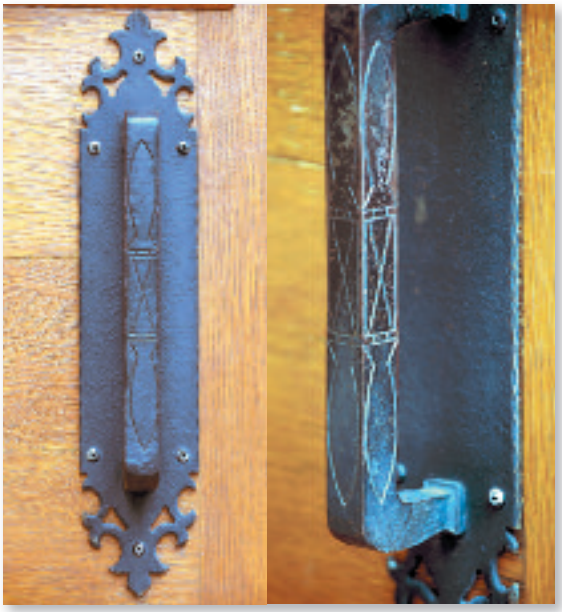


Considered as strip patterns, the designs around the light fixtures in Boe Memorial Chapel have rotation symmetry, glide reflection symmetry, and both a vertical and horizontal axis of reflection.



The Boe Memorial Chapel door handles (above) and the Rølvaag Library ceiling details (below) have rotation symmetry and both horizontal and vertical axes of reflection.

Taken as a whole, the grillwork pattern on this Mellby Hall entryway has a vertical axis of reflection. The columns within the grillwork also can be regarded as segments of strip patterns.

The figure above this Holland Hall doorway has rotation symmetry and both a vertical and horizontal axis of reflection. The decorations on the light can be considered strip patterns. The one around the top has a vertical axis of reflection, while the pattern formed by the white light and the black overlays has glide reflection and rotation symmetry as well as a vertical axis of reflection.

"SYMMETRY IS A KEY ELEMENT, OFTEN THE CENTRAL OR DEFINING THEME, IN ART, MUSIC, DANCE, POETRY, OR ARCHITECTURE. IT PERMEATES ALL OF SCIENCE, OCCUPYING A PROMINENT PLACE IN CHEMISTRY, BIOLOGY, PHYSIOLOGY, AND ASTRONOMY."

— Leon Lederman and Christopher T. Hill, *Symmetry and the Beautiful Universe*

The exterior of Old Main has a variety of symmetric figures and strip and wallpaper patterns. There are patterns in the wood above the windows, metal ornaments on top of windows, two different shingle patterns, and strip patterns in the red-painted wood.

The heads and the central dragon face all have vertical axes of reflection, as does the elaborate design at the base of the picture.

MARA KUMAGAI FINK '11 is a student reporter in the St. Olaf marketing and communications office. She is majoring in political science and sociology/anthropology.

KAY SMITH, MATHEMATICIAN

Kay Smith has been interested in mathematics for as long as she can remember. With a father who earned his doctorate in chemistry and a mother who earned a bachelor's degree in physics, Smith's interest in math was accepted, and encouraged, at a time when few women entered the field.

"Initially I was attracted to math because I like solving problems," she says. "Anyone who has done math can tell you that if you solve a problem, it's exciting — it's your own intellectual high."

Smith completed her undergraduate work at Bucknell University where she had only two female professors — one in English and the other in physical education. Smith also was one of the few women in her doctoral program at Yale University, and there were no female faculty in the math department during her graduate school years.

"I remember one of the male faculty members telling me that you had to have a tough skin to be a woman in math," says Smith.

Her decision to pursue a career in teaching came during graduate school after working briefly in the applied mathematics group at Eastman Kodak Company, where her focus was on product development. "While the work was challenging, it wasn't satisfying to be developing a better product or looking at how to market something more effectively," she says. The experience confirmed that she wanted to work with students.

When Smith began her teaching career, she recognized the importance of having women role models in the classroom. Currently, nine of the twenty-four faculty members in the St. Olaf Department of Mathematics, Statistics and Computer Science are women. "Having so many women in the department demonstrates to all students that women 'can do math.' Too, having a range of personalities — both male and female — and teaching styles gives students a breadth of experience that helps them identify their aptitudes and learning styles," she says.

There are sixty to seventy math majors in each graduating class and enhancing their experience is the strength of the college's outstanding mathematics program. According to the National Science Foundation's *Survey of Earned Doctorates*, St. Olaf ranks first among the country's baccalaureate liberal arts colleges in the number of students who go on to earn Ph.D.s in mathematics and statistics.

"While some colleges focus their math program on the best students, our department believes that courses in mathematics, statistics, and computer science are beneficial for every student," Smith says. "We encourage all students to take as many courses as they can."

EXPANDING HORIZONS

In addition to helping students master the content of their classes, Smith enjoys introducing them to the "bigger picture" — including the importance of symmetry, an idea, she says, best explained by Nobel Laureate Leon Lederman and Christopher T. Hill in the introduction of their book *Symmetry and the Beautiful Universe*:

> "Symmetry is ubiquitous. Symmetry has myriad incarnations in the innumerable patterns designed by nature. It is a key element, often the central or defining theme, in art, music, dance, poetry, or architecture. Symmetry permeates all of science, occupying a prominent place in chemistry, biology, physiology, and astronomy. Symmetry pervades the inner world of the structure of matter, the outer world of the cosmos, and the abstract world of mathematics itself. The basic laws of physics, the most fundamental statements we can make about nature, are founded upon symmetry."

Thanks to Smith, St. Olaf math students will likely never look at the buildings on the Hill — or any building — in the same way ever again.