# 13. Cornbread Are Square

*"Pie are round; cornbread are square"—Anonymous*

In this activity, you will explore the areas of circles.

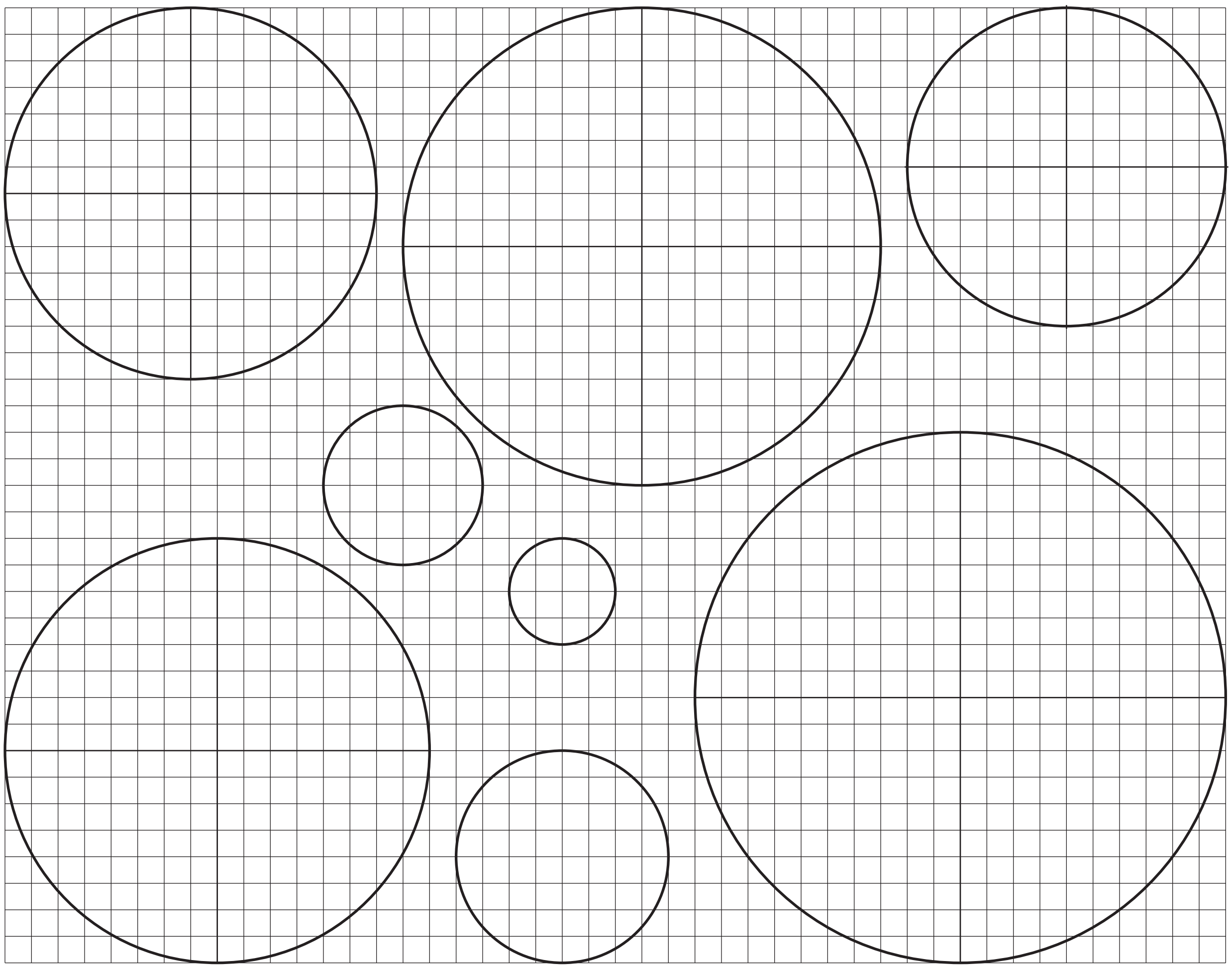
## What to Do

Count the squares in each of the circles below (or you could make your own using graph paper). Count the area in the partial squares as well, estimating how many whole squares they make up together.

You will measure area and radius in the units of the grid.

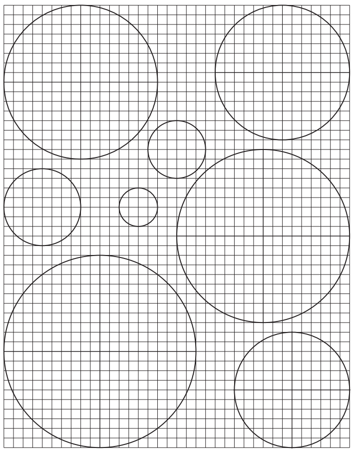
How will **area** be related to **radius**?

- ❏ Predict: What do you think the relationship will look like? Daw your predicted graph. If you can, be precise and quantitative.
- ❏ Record measurements of **area** and **radius** for as many circles as you can.
- ❏ Plot **area** against **radius**.
- ❏ Find and explain a mathematical function that fits the points. Be sure you can explain the meaning of any parameter.
- ❏ Use your function to predict the **area** of a circle with **radius** = 5. Then make the circle and check!
- ❏ Be sure you can explain why the symbolic form of your function makes sense.



# Cornbread Are Square • Instructor Notes

*"Pie are round; cornbread are square"—Anonymous*



This activity presents students with circles on grid paper. The goal is to see how the area of a circle depends on its radius.

Even if students can recite the formula $A = \pi r^2$ in their sleep, the data approach is interesting, because

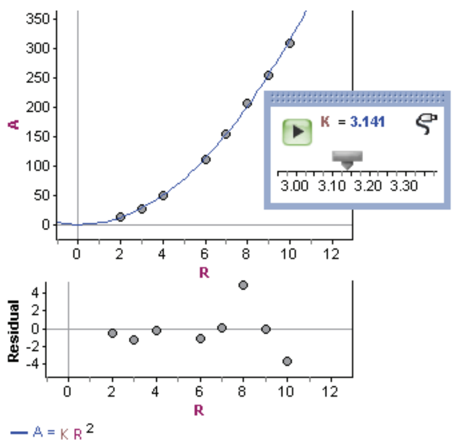
- They may not have thought about what area actually means in a while;
- They may never have had this formula confirmed for themselves; and
- Students may not even think of this formula in this context.

We expect students to count the squares to get the area. They could save work by counting a quarter of the squares in each circle, then multiply by 4. That's fine.

One common way to count the partial squares is to estimate which partials go together to make up whole squares, and shade them in as you count.

## Results

Here is some pretty good data. The residual plot is helpful and illuminating; students will see that the larger circles have more leverage in the residual plot.




## Why Use Functions?

You could just calculate "pi" for each circle, taking the area and dividing by the square of the radius. Why go to the trouble of plotting the function?

For one thing, it shows us the relationship, not just the number.

For another, the numbers get more accurate with larger radii; if we simply averaged the $\pi$s, we would get a skewed result.

Note: you could plot the area against the square of the radius; then you should get a straight line that (limiting cases) passes through zero, and has a slope about $\pi$.

# Cornbread Are Square • More Instructor Notes

## Alternative Approach: Upper and Lower Limits

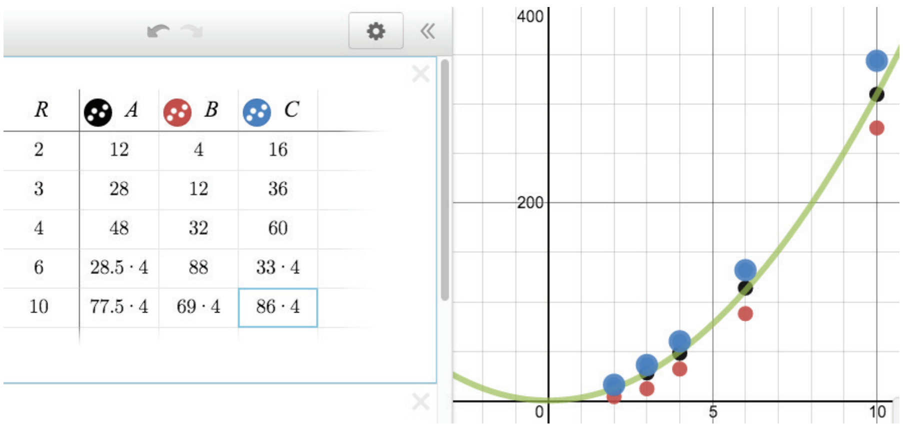
Instead of counting up partial squares, you could have students “bracket” $\pi$ by doing an upper/lower limit dance:

- ❏ Count the squares that are *entirely* within the circle. This “area” is the minimum area.

- ❏ Next, count the squares that contain any part of the interior of the circle. (That is, the interior squares plus all squares the circle goes through.) This is the maximum area.

- ❏ Make one graph of the minima, one of the maxima, and find the parameter that corresponds to each one.

  You can also put both on the same graph; In Fathom, be sure to drop the second variable onto the plus-sign as shown on page 89. In Desmos, just make another “y” column.



| $R$ | $A$ | $B$ | $C$ |
|---|---|---|---|
| 2 | 12 | 4 | 16 |
| 3 | 28 | 12 | 36 |
| 4 | 48 | 32 | 60 |
| 6 | $28.5 \cdot 4$ | 88 | $33 \cdot 4$ |
| 10 | $77.5 \cdot 4$ | $69 \cdot 4$ | $86 \cdot 4$ |