

4.5 PROJECT

WHY ARE CELLS SO SMALL?

The germ theory of disease is the fundamental theory of medicine that says infectious diseases are caused by microscopic organisms called pathogens. The theory wasn't accepted until the end of the 19th century, in part because pathogens are invisible to the naked eye.

A main type of pathogen is bacteria (singular, bacterium). These are one-celled (or unicellular) living organisms present almost everywhere on Earth.

In this project, we will explore one possible reason that bacteria are so small.

In order to simplify matters, let's assume we are going to study a bacterium that is perfectly spherical.

Biologists believe that the ability of a bacterium to obtain resources (such as food) is proportional to its radius. They also believe that the bacterium's need (or demand) for resources is proportional to the square of its radius. If the demand for resources is less than or equal to the ability to obtain resources, then the bacterium is able to sustain itself.

The table below contains the values for the ability to obtain resources (A) and the demand for resources (D) for a hypothetical bacterium. Units are omitted for clarity.

Radius (R)	Ability (A)	Radius Squared (R^2)	Demand (D)
1.5	0.75	2.25	0.45
2	1	4	0.8
2.5	1.25	6.25	1.25

1. Assume that A is proportional to R ; that is, $A = k_1 R$ for a constant of proportionality k_1 . Determine the value of k_1 .
2. Assume that D is proportional to R^2 ; that is, $D = k_2 R^2$ for a constant of proportionality k_2 . Determine the value of k_2 .
3. When the radius doubles from 1.5 to 3.0, how many times does the ability to obtain resources increase by?
4. Determine the demand (D) from a radius of $r = 3$. How many times larger is that than the demand (D) when the radius is equal to 1.5?
5. How can these numbers help explain why most unicellular organisms are usually small?