Oxygen Diffusion in Simple Organisms

# Introduction

Many simple organisms do not have specialized respiratory structures and instead obtain oxygen by diffusion through their body surfaces.

# Importance

We can use a simple equation to assess properties of an organism that can survive by diffusion alone.

# Questions

How is the oxygen need of an organism related to its metabolism and size?

# Variables

|  |  |
| --- | --- |
| S | concentration of O2 required at surface of organism for survival (atm) |
| C | rate of oxygen consumption ((cm3 O2/cm3tissue)/min) |
| r | radius of spherical organism (cm) |
| K | diffusion constant ((cm2/atm)/min) |

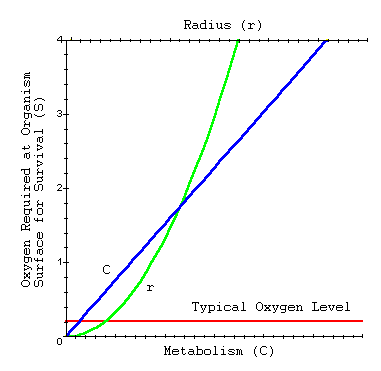
# Methods

E. Newton Harvey (1928) developed the following equation to describe the concentration of oxygen required to supply a spherical organism with oxygen by diffusion:

|  |  |
| --- | --- |
|  | LaTeX Code: \[ S = \frac{Cr^2}{6K} \] |

where S is the required concentration of oxygen at the surface of an organism, C is the rate of oxygen consumption (cm^3 of oxygen/cm^3 tissue/min), r is the radius of the organism (cm), and K is the diffusion constant (cm^2/atm/min).

We can plot S as a linear function of C and as a parabolic function of r. A diffusion constant of 11x10^-6 cm^2/atm/min is typical for many animal tissues



# Interpretation

We can see that as organism metabolism (oxygen consumption) or organism size increases, a greater amount of oxygen is needed at the surface of the organism for survival. Well aerated water typically contains 0.21 atm oxygen. We can compare the intercept S = 0.21 with the graphs of C and r. Even well-aerated water is well below the required oxygen level for organisms of large size or high metabolism.

# Conclusion

By trying hypothetical organisms in the equation, one sees that for an organism to survive by diffusion alone, it must either be very small or have a very low metabolic rate. Larger organisms or those with high metabolic rates must develop respiratory structures in order to meet their oxygen needs.

# Additional Questions

1. How does the slope of S as a linear function of C change with increasing radius? What does this imply about an organism?

# Source

Schmidt-Nielsen, K. 1990. *Animal Physiology: Adaptation and environment*, Cambridge University Press, Cambridge

Harvey, E. N. 1928. *The oxygen consumption of luminous bacteria*. J. Gen. Physiol. 11:469-475.

# About this Resource

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This material is now being revised as part of the “Resources for Improving Quantitative Skills in Community College Biology[[2]](#endnote-2)” project. As part of that project is also aligned with the OpenStax Biology Textbook[[3]](#endnote-3).

It is published using the QUBES Open Education Resources publishing platform[[4]](#endnote-4).

1. http://www.tiem.utk.edu/~gross/bioed/ [↑](#endnote-ref-1)
2. https://qubeshub.org/community/groups/quantbioatcc/ [↑](#endnote-ref-2)
3. https://openstax.org/details/books/biology-2e [↑](#endnote-ref-3)
4. https://qubeshub.org/qubesresources/publications/1081/ [↑](#endnote-ref-4)