Water Movement through a Membrane: The Van't Hoff Equation

# Introduction

The movement of water into or out of cells is a common phenomenon in biological systems. Movement of water is often driven by osmosis: water moves from regions of low solute concentration to regions of higher solute concentration. For example, the digestive tract of many animals is lined with a single layer of epithelial cells, tightly connected cells that play a role in absorption and digestion. In the stomach, there is a net movement of water from the blood across the epithelial cells lining the stomach into the stomach lumen. Metabolic activity of the epithelial cells is responsible for this movement of water.

# Importance

A difference in pressure between the blood and the stomach lumen causes water to flow. We can understand how metabolic activity of the epithelial cells lining the stomach affects the flow of water into the stomach by examining the van’t Hoff equation.

# Questions

How is water flow into the stomach affected by solute concentrations and the activities of the epithelial cells?

# Variables

|  |  |
| --- | --- |
| O | osmotic pressure (atm) |
| R | gas constant (82.06 cm3 atm / mol K) |
| T | temperature (K) |
| Cn | solute concentrations (mol/cm3) |

# Methods

Osmotic pressure is the pressure required to stop the net flow of water across a membrane (or cell layer) separating solutions of different composition. In our case, the membrane is the layer of epithelial cells and the two solutions are the blood and the stomach lumen. The van't Hoff equation describes the osmotic pressure (O) on one side of the epithelial cells and is given by

|  |  |
| --- | --- |
|  | LaTeX Code: \[ O = RT(C\_1 + C\_2 + … + C\_n) \] |

where R is the gas constant, T is the temperature, and Cn are individual solute concentrations for solutes contained in the blood.

# Interpretation

We can determine osmotic pressure for both the stomach lumen and the blood, depending on the concentration of solutes in each. Notice as the solute concentration in the stomach lumen or in the blood increases, the osmotic pressure increases. Water flows in the direction of higher osmotic pressure (higher solute concentration) in order to maintain equal osmotic pressure on both sides of the membrane.

|  |  |
| --- | --- |
| *Osmotic pressure* | *Flow of Water* |
| Ostomach = Oblood | no flow |
| Ostomach > Oblood | flow into stomach |
| Ostomach < Oblood | flow into blood |

Under normal circumstances, osmotic pressure in the stomach lumen and blood are equal (Ostomach = Oblood). When substances enter the stomach, however, epithelial cells actively secrete ions such as H+ and Cl- into the stomach lumen. In doing so, the osmotic pressure in the stomach lumen increases so that Ostomach > Oblood. As a result, water flows into the lumen in order to maintain equal osmotic pressure on both sides. Typically, about 300 to 400 water molecules must be moved per H+ or Cl- ion in order to maintain equal osmotic pressure.

# Conclusion

Movement of water into the stomach depends on the metabolic activity of epithelial cells. By secreting ions into the stomach and changing the difference in ion concentration, they indirectly cause net flow of water into the stomach lumen.

The van’t Hoff equation is widely applicable to many biological situations involving the flow of water. For example, plant cells often enlarge or shrink due to changes in osmotic pressure as changes in the cell membrane result in the movement of ions into or out of the cell.

# Additional Questions

1. If a great deal of water enters the stomach, some water may be absorbed into the blood. Look at the van’t Hoff equation and explain why this might be.

2. How is osmotic pressure affected by changes in temperature?

# Source

Darnell, J., H. Lodish, and D. Baltimore. 1986. *Molecular Cell Biology*. Scientific American Books, Inc., New York

# 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)
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