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# Deliberative Democracy: Desalination

## Alignment with Course Content

This module can be used to reinforce understanding of the thermodynamics of phase changes, intermolecular forces, and solution properties.

## Necessary Background Knowledge

- Thermodynamics
  - Phase Changes
  - Intermolecular forces
  - Osmosis
  - Solutions
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## Policy Issue

Your community has been experiencing drought conditions for 10 years; there is little fresh water available from the local watershed and the aquifer has drawn low. But, you are a coastal community and have ample sea water available.

What would be the best strategy for the community to adopt to assure that all members have access to clean drinking water? Provide the cost/benefit analysis, inclusive of scientific data or principles, to justify the method you choose.

## Module Goals

### Students should be able to:

- Search and utilize published scientific data to construct an argument
- Describe colligative properties and their significance to the policy issue
  - Apply principles of energy transfer to water purification processes Describe the process of osmosis/reverse osmosis
  - Describe the transfer of energy in phase changes

## Deliberation Scaffolding

### Students should consider:

- How much salt is in the original water and how much is recommended in drinking water?
- How/why is salt left behind in each method?
- What resources are required to desalinate in each method?
- What are the energy costs?
- How much drinkable water is produced and in what time frame?
- How efficient are the methods?
- What are the environmental impacts of each method?

## Instructor Notes

### Implementation Suggestions

- This module was implemented as a one day module with guided worksheet (attached).
- The peer-reviewed and media assignment were combined to form one assignment containing questions from both the assigned peer-reviewed and media articles.
- In addition to reading a peer-reviewed and media article for the out-of-class assignment, the class was divided into two groups and each group read one extra supplemental media article to gain extra information about desalination processes (questions about this article were not included in the out-of-class assignment).
- Students were asked to find one credible article describing an additional desalination technique other than reverse osmosis to bring to class on the DD day.

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## Articles

### Media:

<https://www.scientificamerican.com/article/taking-the-salt-out-of-seawater/>

### Peer reviewed:

<http://science.sciencemag.org/content/333/6043/712/tab-pdf>

DOI: 10.1126/science.1200488

### Supplemental Articles:

<http://www.renewableenergyworld.com/articles/2015/06/solar-thermal-desalination-now-underway-in-water-hungry-california.html>

<http://www.npr.org/sections/parallels/2015/06/14/413981435/israel-bringing-its-years-of-desalination-experience-to-california>

## Informative Articles Students Might Find

[Peer Review-Application of Membrane Distillation for desalting brines from thermal desalination plants](#)

[Peer Review-Adsorption desalination: An emerging low-cost thermal desalination method](#)

[Peer Review-Solar thermal-powered desalination: A viable solution for a potential market](#)

[Media-Cheaper, Energy Efficient Ways to Desalinate Water](#)

[Media-Teen finds cheap way to turn salt water into safe drinking water](#)

[Student Proposal-Addressing global water scarcity with a novel hydrogel based desalination](#)

[Government Site- Saline water: Desalination](#)

[Media-Separation by Distillation](#)

[Media-SOLAR POWERED WATER DESALINATION HEATS UP IN CHILE](#)

[Media-Israel Proves the Desalination Era Is Here](#)

[Peer Review-State-of-the-art of reverse osmosis desalination](#)

[Peer Review-Advances in seawater desalination technologies](#)

[Peer Review-Desalination by distillation and by reverse osmosis — trends towards the future](#)

[Peer Review-Energy penalty for excess baggage](#)

[Peer Review-Tunable sieving of ions using graphene oxide membranes](#)

[Peer Review-Carbon nanotube membranes with ultrahigh specific adsorption capacity for water desalination and purification](#)

[Peer Review-Efficiently Combining Water Reuse and Desalination through Forward Osmosis—Reverse Osmosis \(FO-RO\) Hybrids: A Critical Review](#)

[Peer Review-Water desalination system using solar heat: A review](#)

[Science History Institute-Distillations](#)

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## Media Paper (Multiple-Choice Assignment Ideas)

<https://www.scientificamerican.com/article/taking-the-salt-out-of-seawater/>

*Drink Up: Taking the Salt Out of Seawater* by Steven Ashley, Scientific American

Example question topics:

- Chemical processes involved in desalination
- The energy involved in the steps for different desalination techniques
- Comparison of prices between desalination and average municipal water
- Environmental issues with desalination

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## Peer Reviewed Paper (Multiple-Choice Assignment Ideas)

<http://science.sciencemag.org/content/333/6043/712/tab-pdf>

DOI: 10.1126/science.1200488

*The Future of Seawater Desalination: Energy, Technology, and the Environment* by Menachem Elimelech and William A. Phillip.

Example question topics:

- Define the different desalination techniques
- Define portions of Figure 2C
- Dissecting the information in Figure 2B
- Issues with current desalination techniques

Additional content topics:

- Calculating the amount of salt one would drink in a day based on concentration of salt in water
- Calculating the difference in osmotic pressure between areas that have seawater that differs in temperature (must assume only NaCl in the seawater).

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# DELIBERATIVE DEMOCRACY WORKSHEET Drinking Sea Water

| ROLE  | First Name, Last Name<br>(Write clearly!) |
|---|---|
| <b>LEADER (1):</b> keep group on task, keep focus and move forward, wrap up at end                      |   |
| <b>RECORDER (1):</b> fills out form WITH HELP OF ALL GROUP MEMBERS<br>Use a pencil, and write neatly!!! |   |
| <b>SPOKESPERSON (1):</b> presents group ideas/process during break-out                                  |   |
| <b>FACILITATOR (1):</b> make sure everyone speaks, single view doesn't dominate                         |   |
| <b>SUMMARIZER (1):</b> pulls together discussion, identifies "big themes"                               |   |
| <b>DEVIL'S ADVOCATE (2-3):</b> make sure minority views kept alive; "think out of the box"              | 1.<br>2.<br>3.                            |

# DELIBERATIVE DEMOCRACY WORKSHEET Drinking Sea Water

| Questions  | Answers |
|--|---------|
| <p><b>Why is there interest in state of the art sea water desalination technology? Define desalination in your answer.</b></p>                 |         |
| <p><b>List 2 desalination methods. For each method, identify <u>and</u> define the chemistry course topic that the technique utilizes.</b></p> |         |

# DELIBERATIVE DEMOCRACY WORKSHEET Drinking Sea Water

**Compare and contrast two desalination methods addressing:**

- 1. Energy required**
- 2. Efficiency in removing salt  
(consider salt solution concentrations in your answer)**
- 3. Environmental impact**

# DELIBERATIVE DEMOCRACY WORKSHEET Drinking Sea Water

**Your community has been experiencing drought conditions for 10 years; there is little fresh water available from the local watershed and the aquifer has drawn low. But, you are a coastal community and have ample sea water available.**

**What would be the best strategy for the community to assure that all members of the community have access to clean drinking water? Base your strategy on consideration of your answers above.**

**Provide the cost/benefit analysis to justify the method you choose.**

**Additional comments.**