



Renewable Energy From Evaporating Water

BY: BRANTLEY MONTGOMERY

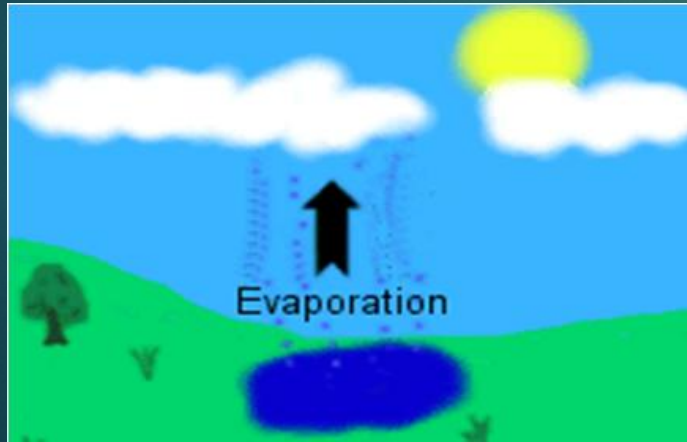
Evaporating Water as Renewable Energy

Overview

- ▶ What is Renewable Energy from Evaporating water?
- ▶ How is the Evaporated Water Harnessed?
- ▶ Bacterial Spores
- ▶ Current Technology : The evaporation-driven oscillatory engine, The rotary engine
- ▶ Disadvantages

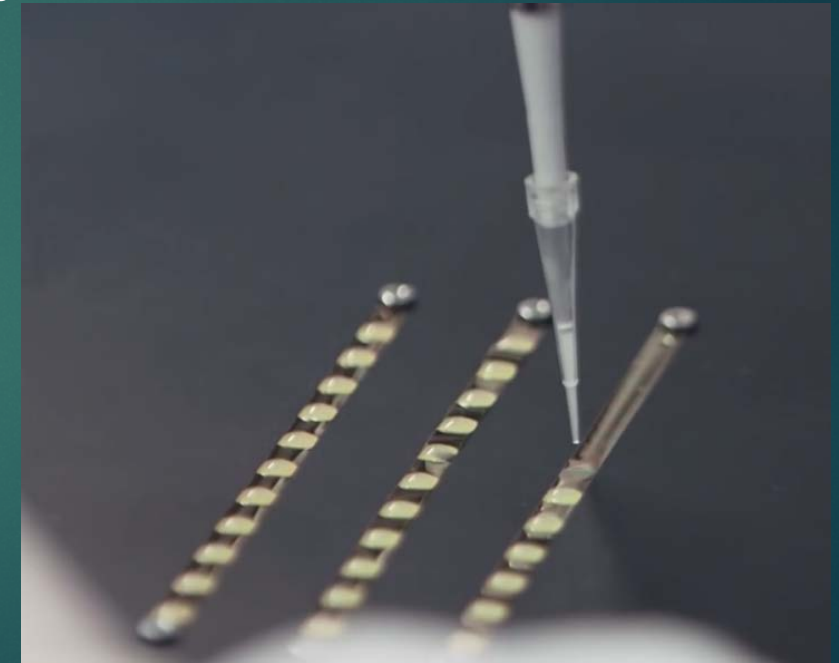
What is Renewable Energy from Evaporating water?

- ▶ The process of converting energy from evaporation, by generating mechanical force in response to changing relative humidity.



How is the Evaporated Water Harnessed?

- ▶ Bacterial Spores (*Bacillus subtilis*) are glued to both sides of a thin, double-sided plastic tape akin to that in cassette tapes, creating a dashed line of spores.
- ▶ Spores are also glued to the other side of the tape, but offset the line so dashes on one side overlapped with gaps on the other making HYDRAs (hygroscopy-driven artificial muscles).



How is the Evaporated Water Harnessed?

- ▶ Dry air shrinks the spores causing the spore-covered dashes to curve. This causes the tape to go from straight to wavy, shortening the tape.
- ▶ If one or both ends of the tape are anchored, the tape tugs on whatever it's attached to. When the air is moist, the tape extends, releasing the force.

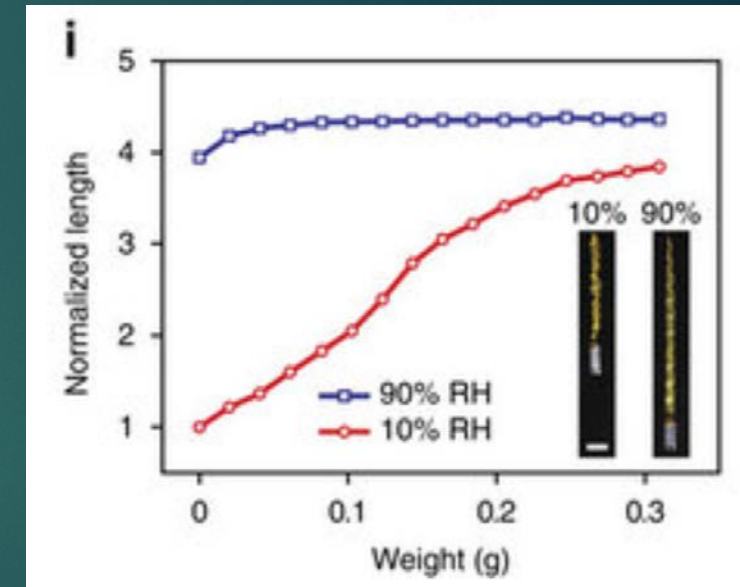
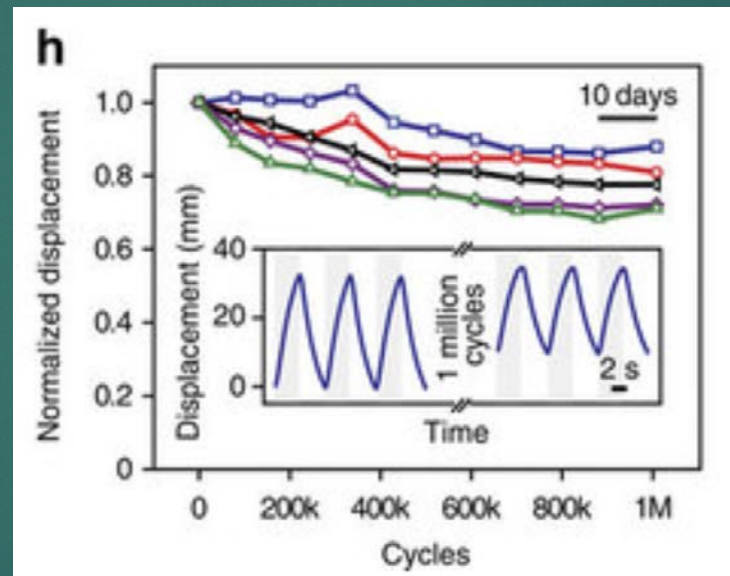
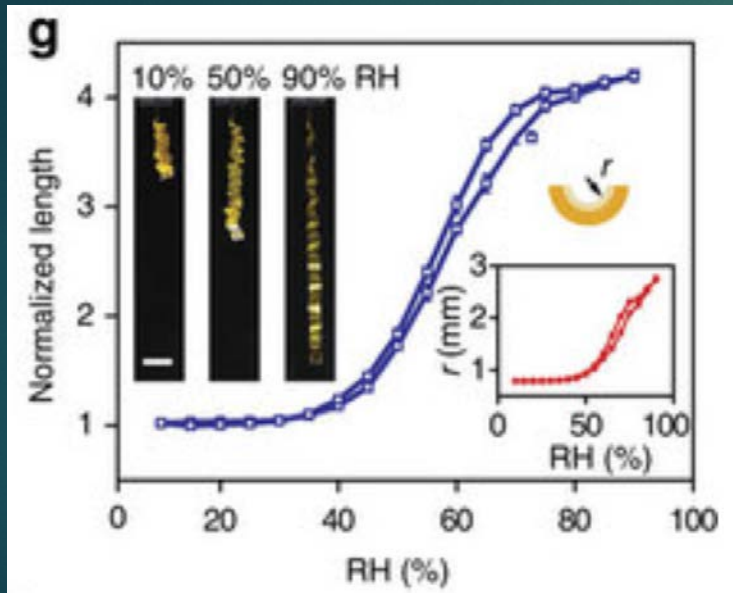


Moisture Increases

Moisture Decreases

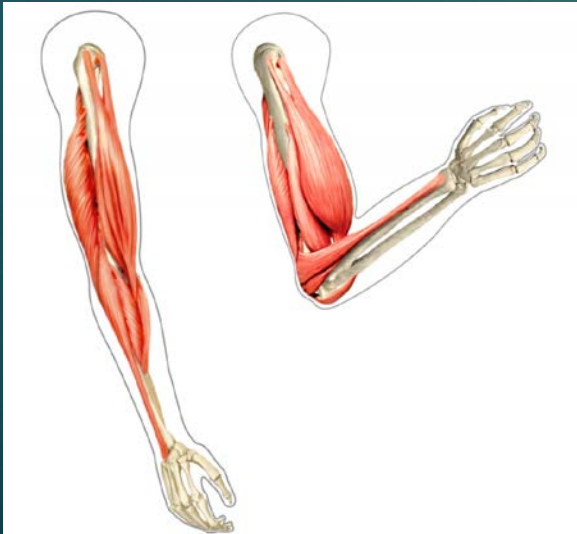


How is the Evaporated Water Harnessed?



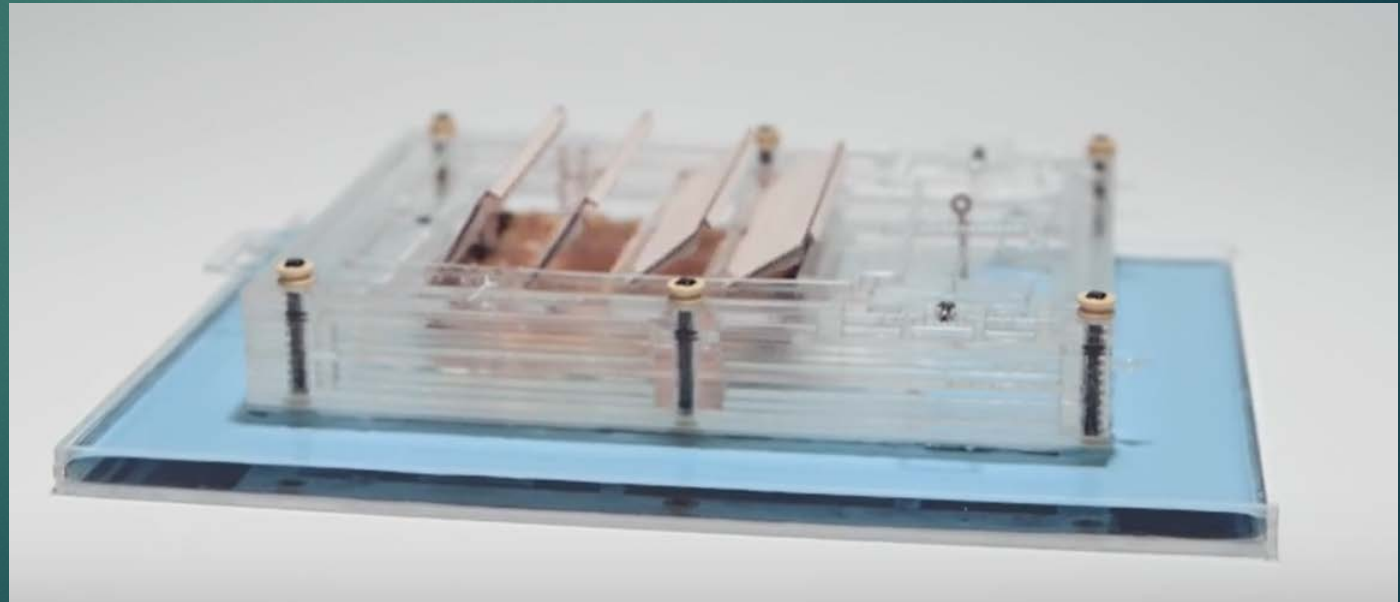
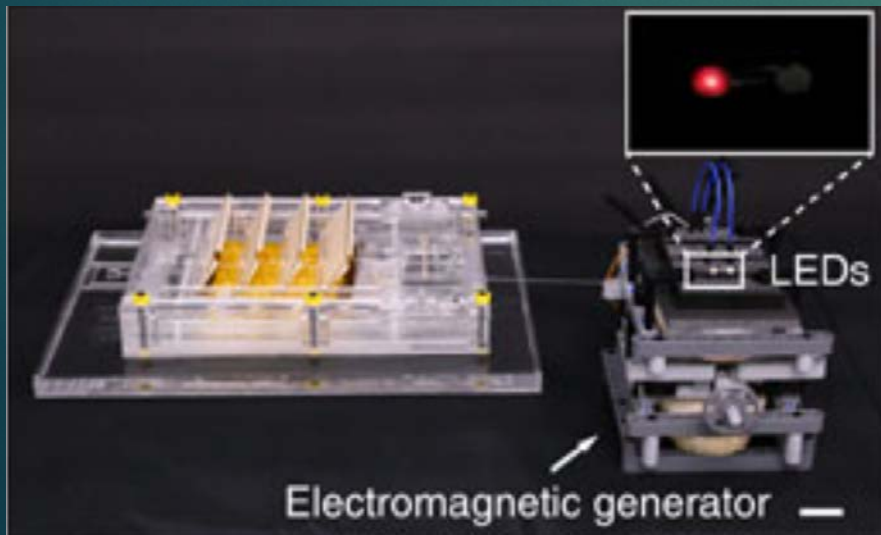
Bacterial Spores (*Bacillus subtilis*)

- ▶ Gram positive (give a positive result in the Gram stain test), rod shaped bacteria, commonly found in soil
- ▶ Endospore forming bacteria which allows it to withstand extreme temperatures as well as dry environments
- ▶ Readily present everywhere; the air, soil and in plant compost



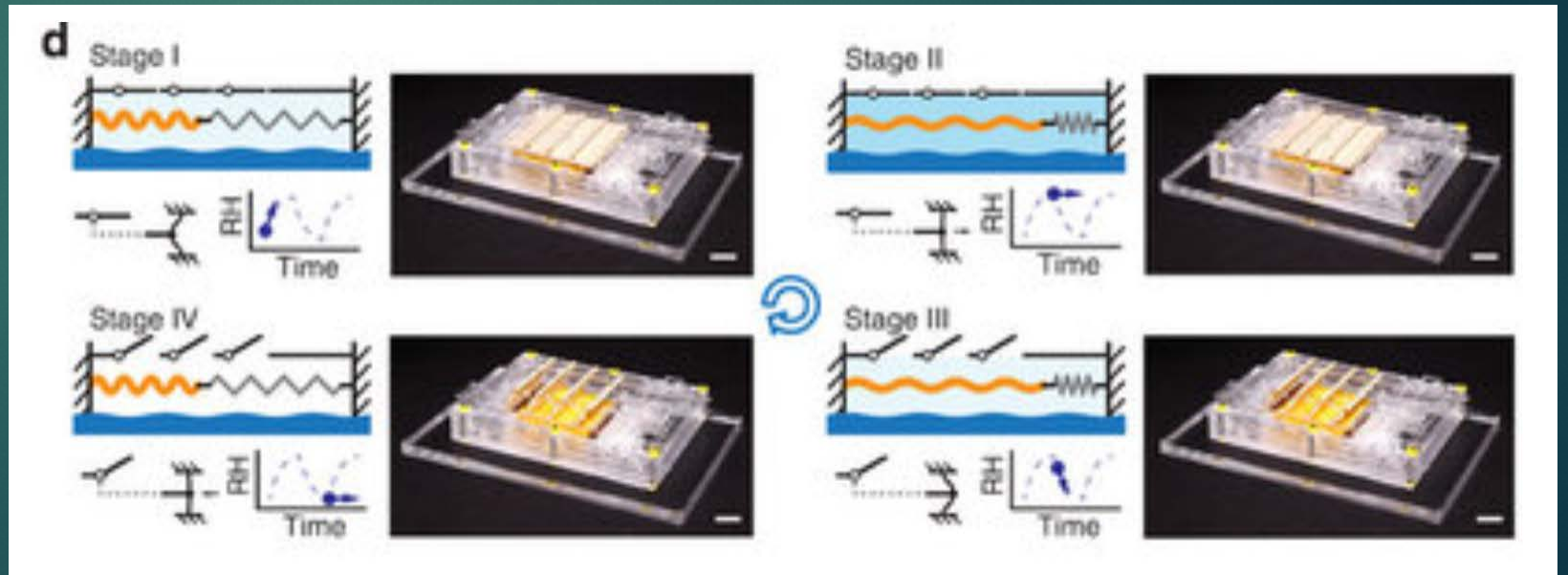
Current Technology: The evaporation-driven oscillatory engine

- ▶ HYDRAs are coupled to a spring and shutters that control permeation of moisture.
- ▶ The shutters, which are connected to a beam that changes position due to the force from the HYDRAs, open and close which change the humidity in the chamber.



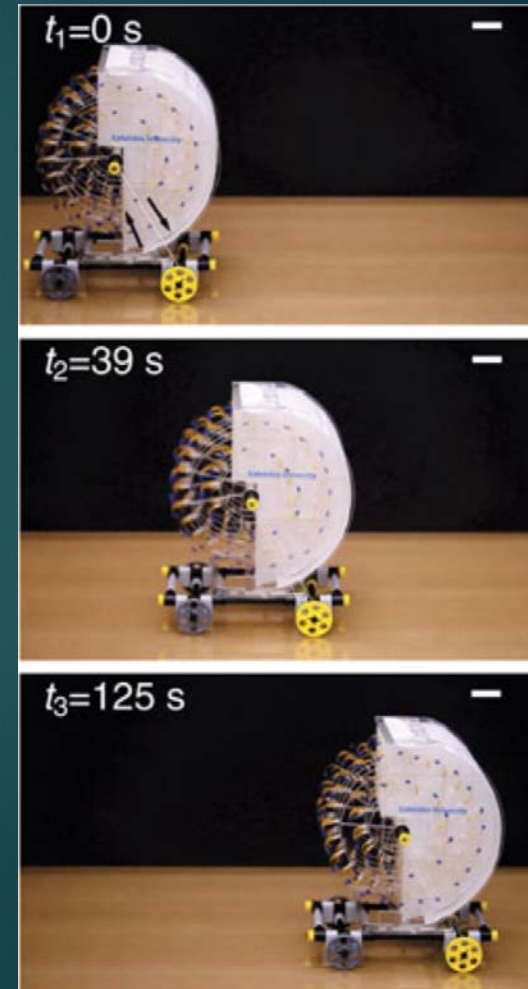
Current Technology: The evaporation-driven oscillatory engine process

- ▶ (Stage I) Shutters are closed \rightarrow humidity in chamber increases \rightarrow HYDRAs expand.
- ▶ (Stage II) HYDRAs expand \rightarrow force beam to switch position.
- ▶ (Stage III) Shutters open \rightarrow moisture leaves chamber \rightarrow HYDRAs contract \rightarrow stage I

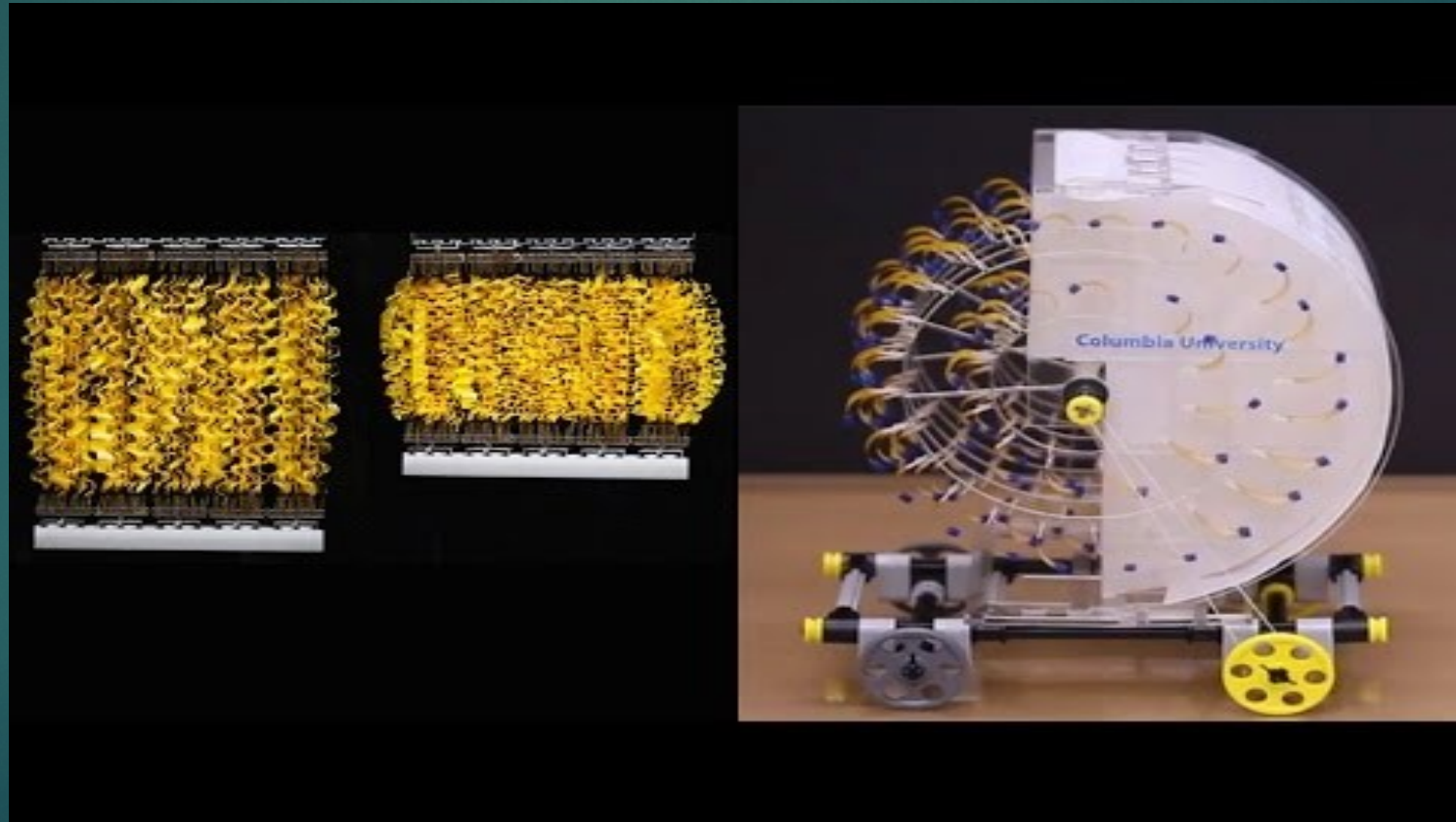


Current Technology: The rotary engine

- ▶ Inserted half way into an enclosure such that the HYDRAs face walls lined with paper
- ▶ Wet paper provides the humidity gradient. Blue plastic blocks weighing 15 mg attached to HYDRAs increase the amount of mass shifting position relative to the axis of rotation
- ▶ The rotation speed depends on the relative humidity outside the chamber and the speed of airflow near the device



Current Technology: The evaporation-driven oscillatory engine and moisture mill video



Disadvantages/Challenges

- ▶ Unfavorable scaling of hydration kinetics slows down actuation speeds at large dimensions
- ▶ Small strains complicate energy transfer to external systems
- ▶ The slow rate of change of relative humidity in the environment limits the power output.



Questions?

References

- ▶ [1] <http://www.sciencedaily.com/releases/2015/06/150616123608.htm>
- ▶ [2] <https://www.youtube.com/watch?v=Vj2kuZm-aCA>
- ▶ [3] <http://www.nature.com/ncomms/2015/150616/ncomms8346/full/ncomms8346.html>
- ▶ [4] <https://www.thinglink.com/scene/508332206804959234>
- ▶ [5] <https://www.youtube.com/watch?v=KQ7nau28qp0>