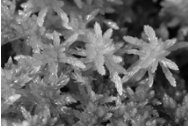


Sphagnum Moss

Spore Dispersal / Boyle's Law
"Spud Guns" and a Voyage to Near Outer Space

J. L. van Leeuwen *Science* 329, 395-396 (2010)
<http://chemconnections.org/general/chem120/Gases/Moss:36%2C000g.pdf>

D. L. Whitaker et al., *Science* 329, 406 (2010) (2010)
<http://chemconnections.org/general/chem120/Gases/Moss-Sphagnum-2010.pdf>

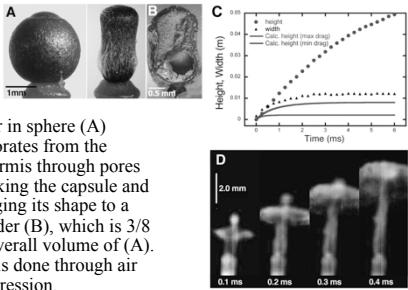


Sphagnum is a genus of up to 350 species of mosses commonly referred to as peat moss. *Sphagnum* species have a dominant sporophyte, and spores are released from specialized black, shiny capsules located at the tips of thin stalks. They also reproduce by fragmentation.

Sphagnum uses wind to disperse its spores. But, the tops of spore capsules are only about 1 cm above ground, and the wind is very weak at this level. So, the spores are discharged by compressed air, which develops as the spore capsule dries. Thanks to vortex rings created during the discharge, the spores reach a height of 10 to 20 cm.


http://en.wikipedia.org/wiki/Sphagnum_moss

Sphagnum capsule transformed from a sphere to a cylinder as it dries, which compresses air that is used to launch / propel spores into the environment

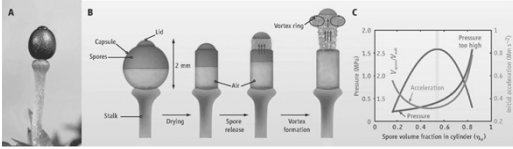


Water in sphere (A) evaporates from the epidermis through pores shrinking the capsule and changing its shape to a cylinder (B), which is 3/8 the overall volume of (A). This is done through air compression.


D. L. Whitaker et al., *Science* 329, 406 (2010) (2010)


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The weakening of the epidermal attachment in the transformed 2 mm cylindrical capsule suddenly ruptures due in part to the increased internal pressure of the compressed air, which propels spores into the environment with an acceleration of 320,000 m/s² (32,000g) to a height of 15-20 cm.




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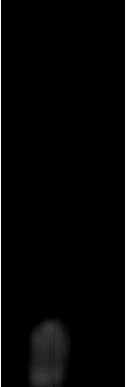
Overall view of spore launch by a *Sphagnum magellanicum* capsule (Recorded at 250 fps; displayed at 15 fps). The vortex bubble is the bright vertical streak moving rapidly upwards leaving a streak of spores in its wake. The cap is visible moving to the left shortly after the explosion. Spores are launched to a maximum height of 143 mm.

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Rupture of the epidermal cap of a *Sphagnum* capsule. (Recorded at 10,000 fps with a 0.097 ms exposure; displayed at 15 fps.) A clear "mushroom cloud" vortex ring forms and reaches a nearly fixed width within 0.5 ms. Spores are carried upward within the vortex ring and its wake.

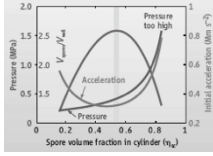
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Explosion of the *Sphagnum* capsule shown in Fig. 1D. (Recorded at 10,000 fps with a 0.020 ms exposure; displayed at 15 fps.) The vortex bubble and trailing wake are visible. The spores in the wake move upwards at a slower rate than those in the bubble. The vortex overtakes and moves past the cap.

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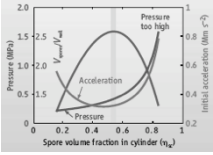
QUESTION



What is the optimum pressure for maximum spore release?

A) 1.6×10^6 Pa B) 7.6×10^3 mmHg
 C) 4 atm D) 1,500 torr

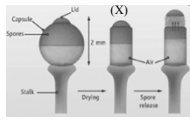
QUESTION



What is the optimum acceleration for maximum spore release?

A) 1.6×10^6 m/s² B) 8×10^5 m/s²
 C) 3.5×10^6 m/s² D) 3.5×10^5 m/s²

QUESTION




What is the final air volume in the cylinder (X) if the air volume in the sphere was 4.20 mm^3 @ 1 atm and the air pressure in the cylinder increased to 3.00×10^3 torr?

A) 1.40×10^{-3} mm³ B) 1.06×10^{-3} cm³
 C) 1.40×10^3 mm³ D) 1.06×10^3 cm³


The Spud Launcher

Mimicking Nature: Potatoes vs. Spores
 How far can you launch a potato using Boyle's Law?
<http://wikipedia.org>



<http://www.youtube.com/watch?v=nkbJaegPY0A&feature=related>

Another Spud Launcher



The projectile (a potato) is loaded into the muzzle (not pictured), which is then attached to the cannon (at 2). The air reservoir (3) is filled to 120 psi (0.83 MPa) using the Schrader valve (4). Upon opening the solenoid valve (1), the air from the reservoir is rapidly transferred to the projectile, which is fired out of the muzzle.

The average PVC pneumatic gun can operate at pressures of ~100 psi (700 kPa); metal pneumatic launchers generate higher pressures, ~500 psi (3.4 MPa). Common potato launching distances are ~200 meters, but 500 meters (550 yd) or greater have been reported.

<http://wikipedia.org>

(Bonus)

Boyle's Engineering Challenge

Design a pneumatic air-launcher that could propel a 125 lb astronaut with life-sustaining equipment, which weighs 250 lbs, to a height of 60,000 ft.

Provide drawings of your device, state the pressure and volumes of air required along with calculations, and any assumptions that you have made in support of your plan.