To investigate the osmotic properties of swim bladder using data loggers

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Introduction

It is suggested in many textbooks that swim bladder of fish is a living tissue that can be used to show osmosis, because it is selectively permeable. And it has been said that when living tissue "died" it will cease to be selectively permeable. However we seldom see the results of correlated experiments reported in the textbooks. Students may doubt if such experiments have actually been tried out to test the claim. The following is a series of investigations spawned from this doubt.

Hypothesis 1

If swim bladder (as a "living membrane") is selectively permeable, then it will demonstrate osmotic properties.

Experiment procedure

- A fresh swim bladder is used to construct an osmometer (see photograph below).
- The bladder is filled with sucrose solution and placed in a beaker of distilled water.
- Pressure sensor is used to measure the pressure change inside the swim bladder.

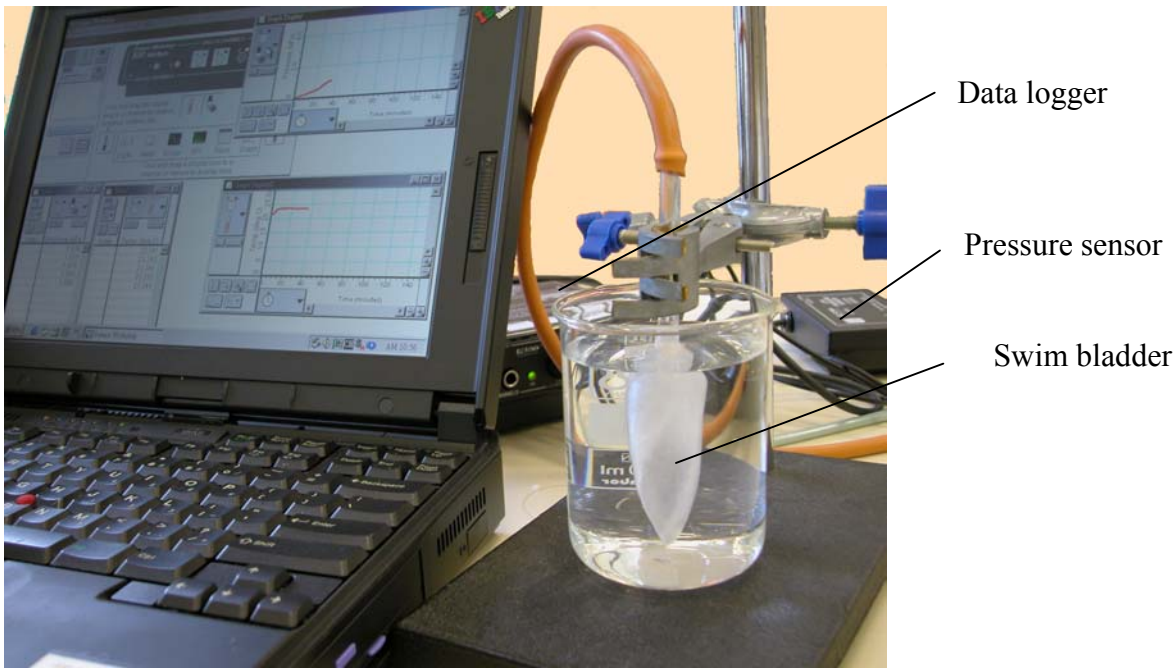


Fig. 1 The setup of the experiment

Result

In the try out experiment two setups were prepared. With both setups running in parallel, the pressure changes within the swim bladders were recorded by a computer. The monitor screen displaying the results was captured and shown below.

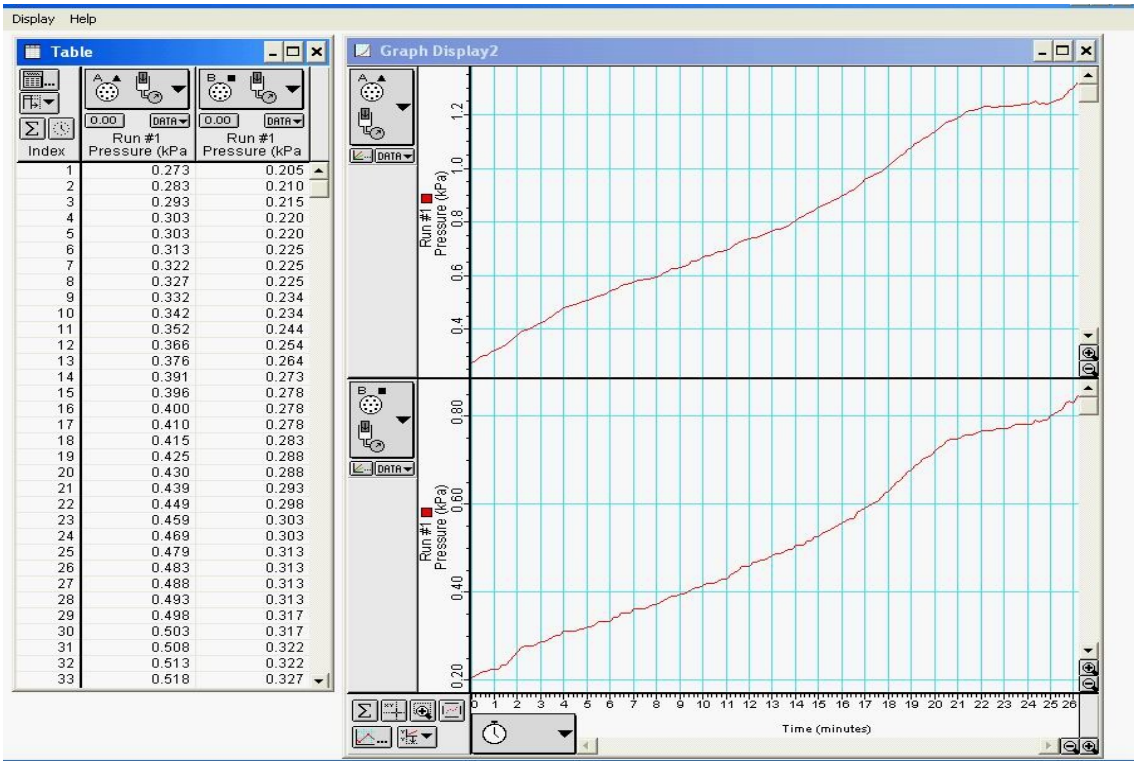


Fig. 2 The results of the try out experiment

Duration (min)	26

	Initial pressure (kPa)	Final pressure (kPa)	Pressure Change (kPa)
Set-up A	0.273	1.323	+1.05
Set-up B	0.205	0.85	+0.645

Both setups recorded a significant increase in pressure within 26 minutes, which is quite good. And if allowance is made for the differences between individual setups, by adjusting the scale of the vertical axis, the curves plotted will bear striking resemblance (as shown in Fig.2).

Conclusion

The rise in pressure was probably due to osmotic intake of water. The experimental results support the hypothesis that swim bladder (as a "living membrane") is selectively permeable. The experimental results also show that swim bladder is an appropriate material for the study of osmosis.

Hypothesis 2

If the tissue of swim bladder is "killed" by boiling, then the membrane will cease to be selectively permeable, and osmosis will not occur.

Experiment procedure

- A fresh swim bladder is boiled until it appears well done.
- The boiled swim bladder is used to construct an osmometer as before.
- The bladder is filled with sucrose solution and placed in a beaker of distilled water.
- Pressure sensor is used to measure the pressure change inside the swim bladder.

Result

The monitor screen displaying the results was captured and shown below.

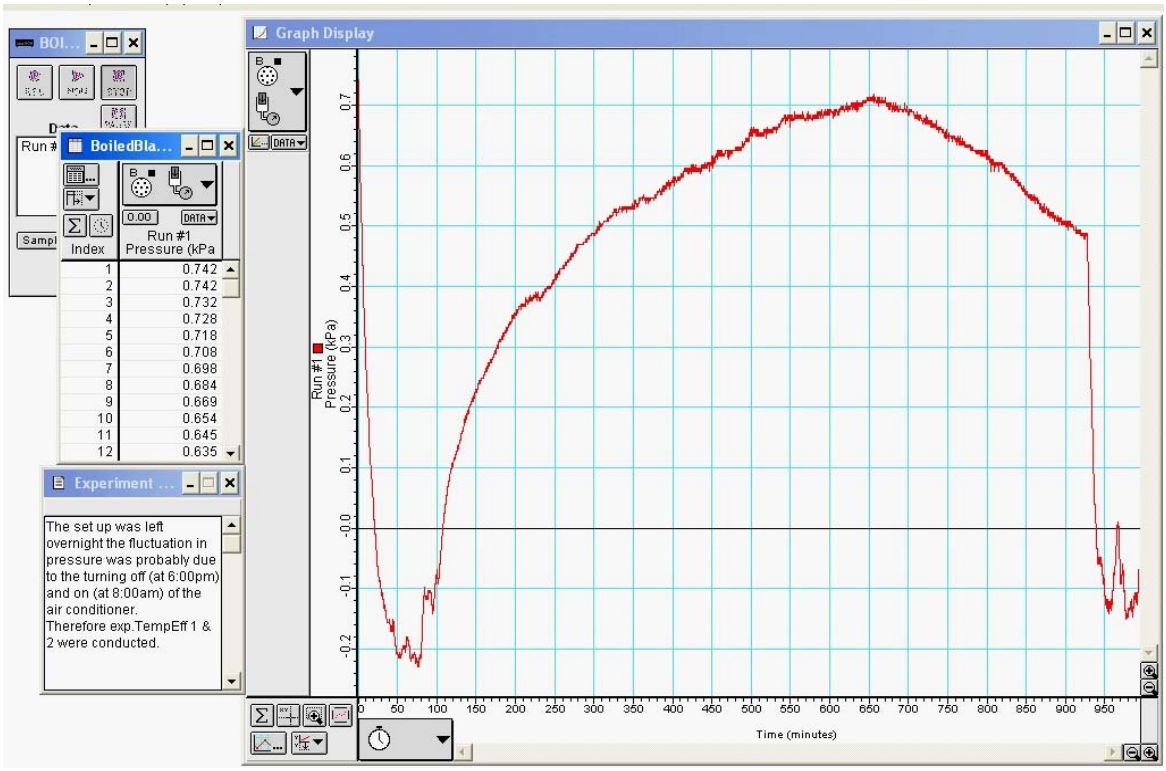


Fig. 3 The results of the boiled swim bladder

Duration	16 hr. 33 min

Initial pressure (kPa)	Final pressure (kPa)	Pressure Change (kPa)
0.742	-0.068	-0.81

At the end of experiment, a net decrease of pressure was recorded. But the experiment obviously did not run a steady course. The pressure dropped markedly in the first one and a half hour. Then the pressure gradually rose for the next six hours. At that moment, the

pressure has almost risen back to the starting value. Four and a half hour further into the experiment the pressure gradually dropped. During the last hour, the pressure dropped markedly again.

Discussion & Conclusion

Despite the fluctuation, the pressure inside the swim bladder has never reached a value higher than the initial pressure. It was either below or almost level with the initial pressure. The experimental result supports the hypothesis that if the tissue of swim bladder is "killed" by boiling, then the membrane will cease to be selectively permeable, osmosis will not occur.

However, the result of this experiment leads to the following questions:

1. If boiling can destroy the selective permeable property of swim bladder, how about freezing and drying?
2. What caused the rise of pressure from the second (6 pm) to the fifteenth hour (8:30 am)?
3. What caused the fall in pressure in the swim bladder during the last hour in an office setting?

Hypothesis 3

If the tissue of swim bladder is "killed" by freezing and drying, then the membrane will cease to be selectively permeable, osmosis will not occur.

Experiment procedure

- A fresh swim bladder was hung in ambient air and allowed to dry for days (see below).

Fig. 4 Photo of dried swim bladders

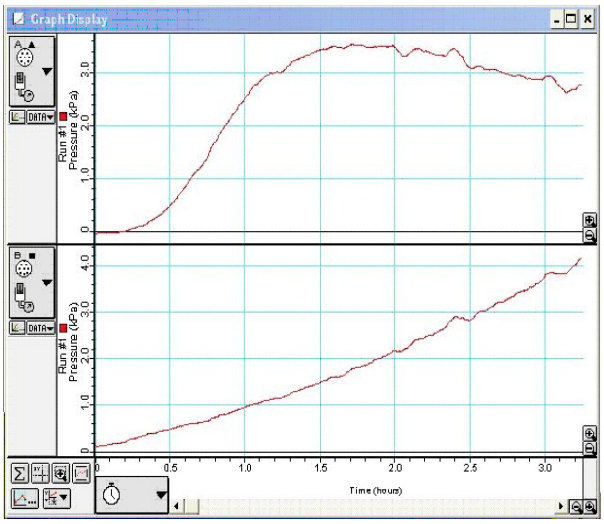
- Another fresh swim bladder is left frozen overnight, in the freezer compartment of a domestic refrigerator.
- Both swim bladders were soaked in tap water at room temperature for 20 minutes.
- Osmometers are constructed with the swim bladders.
- The bladder is filled with sucrose solution and placed in a beaker of distilled water.
- Pressure sensor is used to measure the pressure change inside the swim bladder.

Result

The monitor screen displaying the results was captured and shown below.

Result of dried swim bladder:

Result of frozen swim bladder:



Duration	3 hr. 15 min

	Initial pressure (kPa)	Final pressure (kPa)	Pressure Change (kPa)
Dried swim bladder	-0.039	2.793	2.832
frozen swim bladder	0.142	4.224	4.082

The dried swim bladder:

After drying, the swim bladder looked translucent and papery. After soaking, the swim bladder looked and felt like a normal fresh bladder again.

In the first two hour of the experiment, the pressure within the swim bladder varied to give a typical S shaped curve when plotted. At first the pressure increase was very slow, but the rate of increase gradually increased. Then the pressure increased for some time at a fairly constant rate. At about 1 hr. 15 min. after the commencement of the experiment, the rate of pressure increase flattened off gradually. In the last hour of the

experiment, a slow and steady decrease in pressure was observed. At the end of the experiment a net pressure increase of 2.832 kPa was recorded.

The frozen swim bladder:

After soaking, the frozen swim bladder looked and felt just like a normal fresh bladder. Throughout the experiment period, a steady increase of pressure was shown. The result was very similar to that of the try out experiment (c.f. Fig.2) except that the experiment was allowed to run for a longer period of time and a higher final reading was obtained.

Discussion & Conclusion

Despite the treatments upon the swim bladders, both setups recorded a significant increase in pressure. The pressure increase is probably due to water gain through osmosis, the hypothesis is evidently refuted.

Subsequent to this experiment, the followings are some of the propositions worth investigating:

- the tissue of swim bladder is NOT "killed" by freezing and drying;
- the swim bladder of non-living tissue is still selectively permeable; &
- osmosis will occur without a selectively permeable separating medium.

Points for reflection

What are the differences between the changes brought about by freezing, drying and boiling?

List of Content	Directory and Path
▪ Teacher reference	drive:\sharing\swimbladder\swimbladder.doc
▪ Student Handout	drive:\sharing\ swimbladder\swimbladderhandout.doc