SCIENCE ON THE MOVE TASK 2: YEAST ★

LYCEE JEAN-PIAGET CLASS 2M11 ★

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Acknowledgments

Many souls have been of tremendous help to us, the 2M11, during the entire "competition." Listing all the ways in which they helped us would require a few thousand more pages than we have at our disposition so we are forced to select one or two aspects only. We just want the reader to be aware that we owe them a great more deal than can be written here and we hope none of our helpers gets flouted by any omission. First of all comes, naturally, our science teachers who graciously and uncomplainingly worked long extra hours to support us. They all have families and we can well imagine the sacrifice this "overwork" represented. Their presence was a great source of solace; their patience and willingness to assist us often seemed without bounds. We particularly thank Mr Wintgens for having convinced us to join Science On The Move and overseeing the entire project, Mrs Soldevilla for her great logistic help in using her computing skills to create a file sharing website just for us, Mr Devaud for his valuable comments and sharp remarks and magnanimity (we used up countless physic lessons for this project – a major inconvenience for him which he endured silently and smilingly), Mr Grenacher for his keen and humorous availability and his always sound advice. All of them generously provided much time from their lessons to be devoted to SOTM. We also are indebted to our laboratory operator, Mr Mathez-Neels, who went out of his way to prepare solutions for us and was always there to answer any questions concerning the lab material.

The SOTM adventure was shared; it can be said, by the whole school: a visual arts class participating in a nationwide science event isn't a common happening. Our janitors closed an eye if some of us used the computer rooms longer than allowed, and their cheerfulness was contagious.

Part 1

One simply could not do away with phosphorus, or the many chemical compounds related to this element invariably known as *phosphate*. From our teeth to deoxyribonucleic acid (DNA), the functions of phosphorus and its derivatives are as numerous as they are varied and important. But most of all, "*cells store the energy obtained from nutrients in molecules of adenosine triphosphate* (ATP)"[1] that "*are the general and unique energy currency of living systems on Earth*".[2] Needless to say how vital energy is for all life, be it a lump of horseradish – who uses it to grow - or your average West Coast Gangsta rapper, whose energy consumption notably fuels rhyme-writing, crotch-clutching and other microphone-yielding activities.

Yet there is a dark side to it: "*Some of the most toxic substances known to man…are organic derivatives of phosphorus*."[1] For instance, to freshwater fish of the *Coregonus* genus - a staple in the Swiss fishing industry - an excessive level of phosphates in its aquatic environment is a sure harbinger of an early and painful demise. This phenomenon, commonly known as eutrophication, is mainly caused by the entry into the ecosystem of large quantities of nutrients, viz. nitrate and phosphorus. Runoffs from agricultural fertilization and sewage are to blame for that. In such unnaturally rich waters, algae and microorganisms thrive in what is known as *blooms*; so much that they oversaturate the system with oxygen. This in turn wipes out or permanently alters animal life, when extreme.[3]

Happily, though, the blight of eutrophication can be cured by science. There exists a whole panel of microorganisms capable of uptaking or "absorbing" phosphate, thus purifying the too-rich water. One of these is none other than yeast, that perennial fermenting ingredient for bread (and beer!) making, known to nerds as *Saccharomyces cerevisiae*. Interestingly, the rate at which yeast uptakes phosphate is submitted to large variations dependent on a plethora of external factors. Some starry-eyed scientists even went so far as to rocketing cultures of it into space, as "*S. cerevisiae* exposure to UV irradiation in space causes rate changes involving phosphate uptake."[4]Sadly, shuttling away yeast aboard the transearth Extra Vehicular Activity of Apollo 16 is beyond our means. Yeast stocks up a substantial proportion of phosphate in the cell's vacuole, "the location of >30% of [it] in the form of polyphosphate."[5]

Because phosphorus is so scarce in nature and plays such a role in organic energy creation, many fertilizers use phosphates to artificially boost crop activity, i.e. *growth.* These in turn cause eutrophication as they contaminate the ecosystem. That is why natural microorganisms capable of "helping" crop plants "find" phosphorus (P) are so precious, as this citation farther expounds:

> In an increasingly resource-conscious world, there are hopes that we can exploit this mutualistic association [between fungi and plant root] to reduce the demand for P-fertilizers, both in forestry and agriculture. Second, fungi play a major role in the mineral cycling of P in ecosystems. Problems associated with eutrophication, particularly of enclosed waterways, have highlighted the need for a better understanding of the P cycle. [6]

We couldn't possibly agree more.

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[1] The Encyclopaedia Britannica entry for *phosphorus*, retrieved May 6, 2013 from http://www.britannica.com/EBchecked/topic/457568/phosphorus-P/5698/Principal-compounds

[2] The Encyclopaedia Britannica entry for life (biology), section ATP. Retrieved May 15, 2013 from http://www.britannica.com/EBchecked/topic/340003/life/279351/ATP

[3] Spaak P. 2012. "Les séquelles de l'eutrophisation". *Eawag News*, issue 72. June 2012. p 4. Switzerland.

[4] Berry D., *et al*. 1979. "Phosphate Uptake in Saccharomyces cerevisiae Hansen Wild type and Phenotypes Exposed to Space Flight Irradiation". *Applied and Environmental Microbiology*. Oct. 1979. p 753. Eastern Michigan University, Ypsilanti.

[5] O'Shea E.K. *et al*. 2001. "Phosphate Transport and Sensing in *Saccharomyces cerevisiae*". *Genetics*, issue 159. Dec. 2001. University of California, San Francisco.

[6] Beever R. E. *et al*. 1980. "Phosphorus Uptake, Storage and Utilization by Fungi". *Advances in Botanical Research*, vol. 8. p 129. Academic Press, London.

Part 2

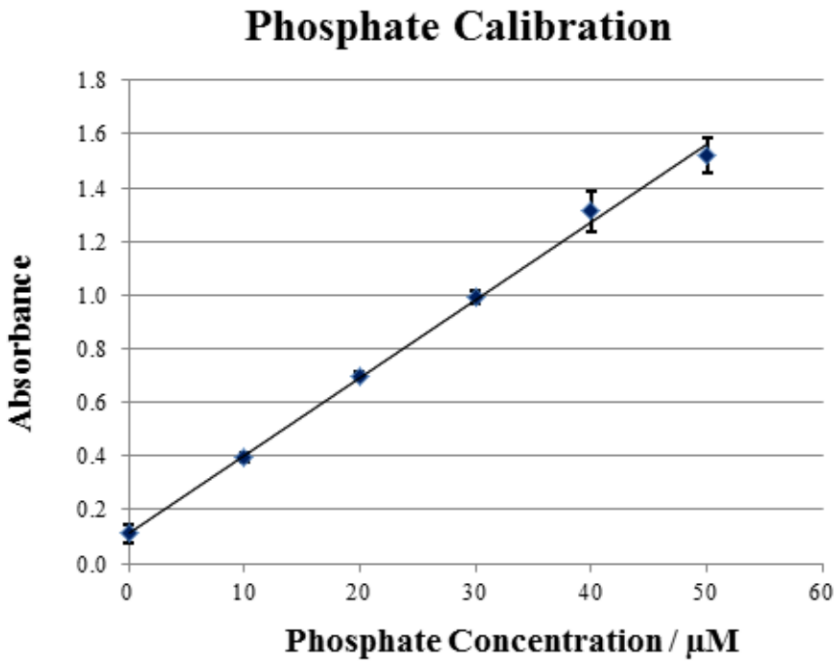
Tables of raw data presenting our three best results:

Value Table 1		
Tubes (EPs)	**Concentration (µM)**	**Absorbance (595nm)**
0	0	0.147
10	10	0.409
20	20	0.704
30	30	1.002
40	40	1.302
50	50	1.523

Value Table 2		
Tubes (EPs)	**Concentration (µM)**	**Absorbance (595nm)**
0	0	0.091
10	10	0.403
20	20	0.683
30	30	0.962
40	40	1.245
50	50	1.458

Value Table 3		
Tubes (EPs)	**Concentration (µM)**	**Absorbance (595nm)**
0	0	0.094
10	10	0.375
20	20	0.713
30	30	1.009
40	40	1.395
50	50	1.587

Our pretest results.



This graph shows the mean value of the results as well as their standard deviation.

$y = 0.0289x + 0.1171$

$R^2 = 0.9976$

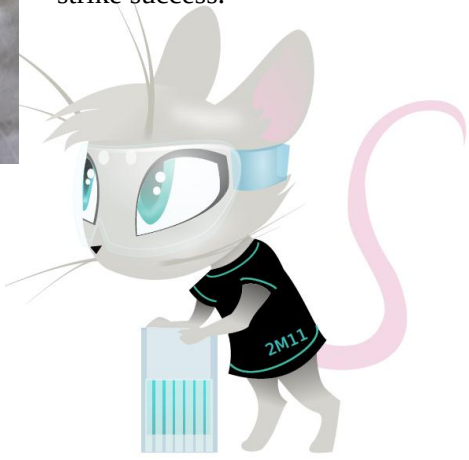
Discussion

Figure 1 - Learning precision – the hard way.

Quite surprisingly, our first troubles were due more to a want of effective organization than anything else. At first, the three groups we had appointed to the task worked more or less independently from each other without much communication between themselves. This, of course, was a big mistake. More than once our lack of coordination created "traffic jams" in front of the photospectrometer, which would plunge everything in dire jeopardy because our agreed-upon 55 second lapse of time just couldn't be respected. We also ended up with incoherent results; we deduced our rigour-lacking pipetting technique was to blame as we often changed the person handling the dosage tools. We finally discovered that actually the photospectrometer hadn't been correctly adjusted.

Our rough and tumble beginnings in the arcane art of pipetting and all our initial fiascos weren't without compensation, though: they taught us a great deal about some elementary management, scientific method and team work principles. When we restarted the experiments, our collective discipline was better and our determination to prevail strengthened by all the earlier mishaps. The results of the second round were thus much more convincing: the correct procedure had sunk in and we nimbly dodged most of the traps and pitfalls into which we had fallen head first before. Nevertheless, one of the groups was still obliged to do a third series of tests in order to strike success.

Figure 2 - Now who said science and art don't mix too well? This blue seems like it was taken straight out of a Raphael!

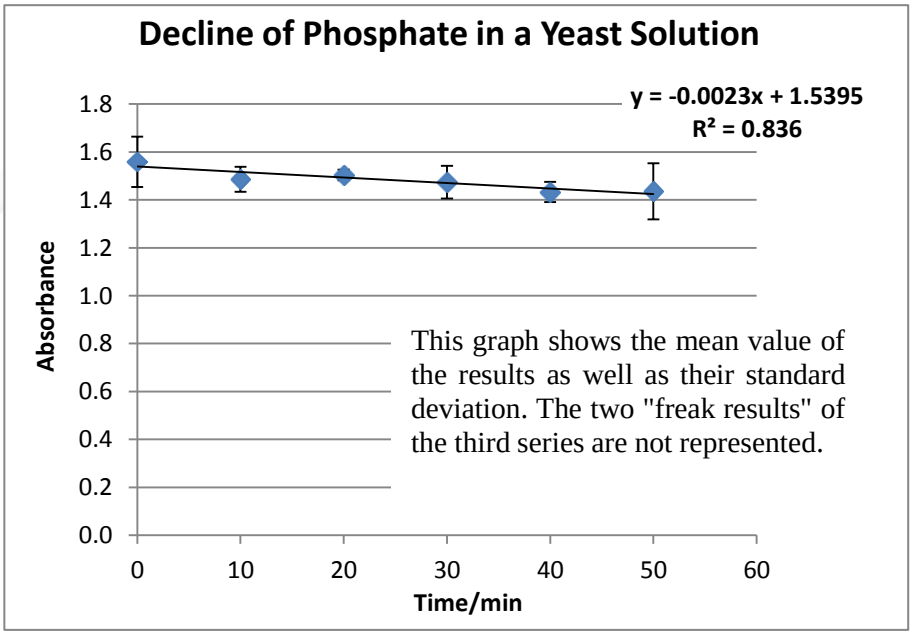


Part 3

As opposed to the previous calibration exercise, where efficient organization had to be learnt, the challenges we faced during this experiment were all rooted in our imperfect scientific method. The results of the first three series of tests weren't too satisfactory: as the chart below shows, our trendline is almost horizontal, indicating that the yeast did very little uptaking at all. Some freak results (see footnote) occurred for yet obscure causes, but by omitting them we can reach a moderately convincing R^2 value at ~ 0.84.

We modified the initial volume of medium from 10ml to 25ml, for what we saw as practical reasons, thus multiplying all quantities by a 2.5 ratio (which, in itself, didn't change anything – we even kept these quantities for some of our subsequent measurements). In fact, we mistook a 25ml volumetric flask for an Erlenmeyer tube and thought it handier if this volume was used. Since the head of a volumetric flask is very narrow, we could only pipet the 300µl aliquot from the surface of the concoction, by fear of having it spill. Unfortunately, we also used a magnetic stirrer and not a stirring rod: the magnet at the bottom of the flask didn't mix well the top of the solution. Accordingly, whatever we pipetted wasn't optimally blended, and perhaps this goes some way to explaining why the phosphate hadn't been effectively uptaken by the *Saccharomyces cerevisiae*.

Value Table 1		
EPs	**Time/min**	**Absorbance (595nm)**
0	0	1.674
10	10	1.434
20	20	1.520
30	30	1.444
40	40	1.385
50	50	1.353
Value Table 2		
EPs	**Time/min**	**Absorbance (595nm)**
0	0	1.537
10	10	1.539
20	20	1.488
30	30	1.552
40	40	1.465
50	50	1.519
Value Table 3		
EPs	**Time/min**	**Absorbance (595nm)**
0	0	1.467
10	10	1.484
20	20	0.620[1]
30	30	1.426
40	40	1.448
50	50	2.719[1]



[1] These two results have not been used in calculating and representing the mean value. The reason is that both these samples presented abnormal characteristics immediately prior to measurement. The 0.620 one was suspiciously light and different in colour, whereas the (horrendous!) 2.719 sample was turbid, khaki green and presented precipitation. According to our teachers, data may be ignored only if serious abnormalities are observed, as here.

Part 4, Glucose Approach

Yeast needs ATP (i.e., *energy*) to do any king of work such as fermentation, phosphate uptaking or multiplication, and glucose is required to produce ATP. So if we modify the quantity of glucose the yeast is exposed too, this must affect ATP production and, incidentally, phosphate uptaking.

In this case the independent variable is the glucose concentration, the dependent variable the phosphate uptaking ratio, and the controlled variable the time span during which the phosphate solution was exposed to the yeast.

In part 3 we had mixed 2.5g of fresh yeast to 25 ml of 0.5mM Sodium-Phosphate-Buffer, pH 6.3, as well as 0.25g of glucose. This solution's glucose concentration was, then, 1%. In this present experiment we first blended 2.5g of fresh yeast to 25 ml of 0.5mM Sodium-Phosphate-Buffer, pH 6.3 with 0.3g of glucose. Accordingly, in this first experiment of May 10, the glucose concentration was of 1.2% or 20% more than that in part 3. In the following May 15 test we changed quantities by blending 1g of fresh yeast with 10 ml of 0.5mM Sodium-Phosphate-Buffer, pH 6.3. We added 0.14g of glucose – giving a concentration of 1.4%, superior by 40% to that in part 3.

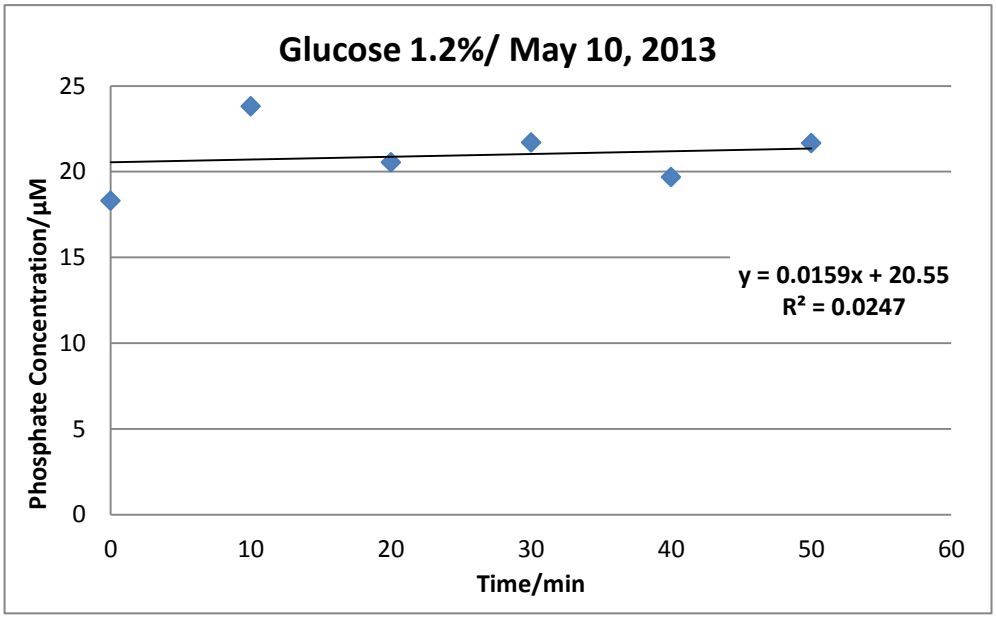
As in part 3, the measurements were made for 6 different samples, pipetted at 0, 10, 20, 30, 40 and 50 minutes, which gave us our controlled variable. For more details concerning our measurement technique, the reader should refer themselves to the corresponding part 3 instruction sheets of the second task of the 2013 Science on the Move competition, as – save for the modified glucose concentration – we copied the process given there step by step for this experiment.

Discussion 1/3

May 10, 2013 test at glucose concentr. of 1.2%			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	0.646	18.30
10	10	0.805	23.80
20	20	0.711	20.55
30	30	0.744	21.69
40	40	0.686	19.69
50	50	0.743	21.66
May 15, 2013 test at glucose concentr. of 1.4%			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	0.466[1]	12.07
10	10	1.672	53.80
20	20	1.078	33.25
30	30	1.591	51.00
40	40	1.247	39.10
50	50	1.358	42.94

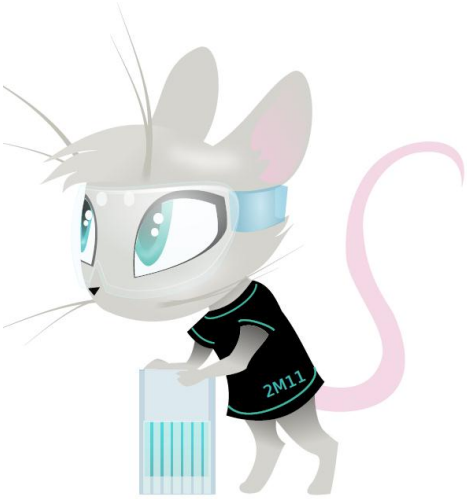
Even a casual glance at our tables and graphs would suffice to understand that something, somewhere, went very, very wrong. The deadline beckoning, we must brace ourselves for facing the fact that realistically speaking, these are the results we will have to present – these or nothing. Because from part 3 onwards, we have been stumbling from fiasco to fiasco; not one chart is even close to being trustworthy. From part 3 onwards, we failed to come up with convincing figures. These are the cards in our hand, like it or not it is up to us to identify and learn as much as we can from our mistakes in order to never repeat them again. This calls for a humbling moment of collective introspection. We must search in ourselves with as much earnestness and penetration as we can muster the true causes, internal and external, of our debacle. Let this be a deep and enriching lesson in humility and self-criticism for all of us.

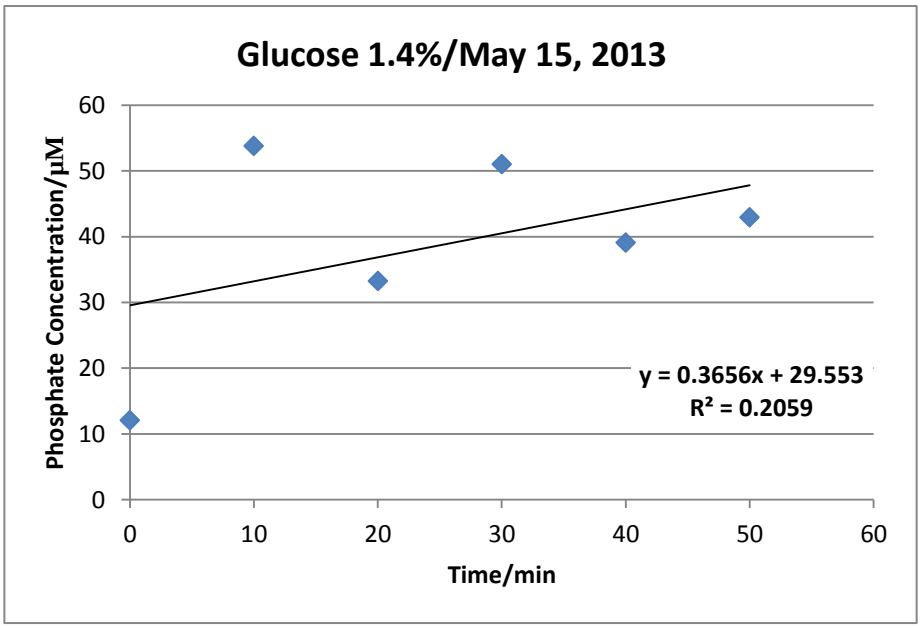
[1] Here we observed that the malachite which had been used to tint the solution was abnormally light in colour and contained small particles. We deduced that malachite tube had been contaminated, and for the rest of the measures we used another tube containing darker, more normal malachite. For this specific measure, however, it was too late.



We carried out all experiences of part 4 more or less simultaneously so it is difficult to dissect the entire operation in three and analyse the methodical faults and cracks for each of the "approaches" separately. The main risk would be repetition. Even minutiae like a questionable technique of blending yeast into the phosphate buffer affect the trio of part 4's experiments, since the three yeast solutions were prepared in the same session. Maybe that in itself is revealing, possibly it could have been wiser to do each step one by one, at the cost of doubling or tripling the time spent in the laboratory. All this made us decide to write only one "discussion" text for the three methods, which will be cut in thirds divided into the three sections of part 4. This is principally due to our sets of numbers being often too botched for decent comparison and commenting that could have enabled us to treat each experiment by itself. We have also set our minds on a specific approach: we shall start with generalities and move down to details; from the forest to the tree to the leaf.

The first, most recurrent and biggest difficulty was our class size of 23. Multitude begets diversity which obviously implies wide variations in motivation and scientific capabilities. More importantly, as the experiments often require no more than 7 or 8 people at a time, if at all, most are not present in the lab. This means that whatever practical knowledge the small group learns first hand, the large one doesn't. What's more, the class "rotated" after each experiment to insure everyone's participation. The consequence was that many of the people participating in each experiment were actually "precision pipetting" for the first time in their lives. A substantial portion of the class didn't really understand what was going on, why we were doing this or that, where we were heading. When those people were put in front of cuvettes and told by others only slightly more knowledgeable and experienced to carry out measurements requiring accuracy to the µl level in a given time limit, the risk of inaccuracies slipping in became very high.





Part 4, Temperature Approach

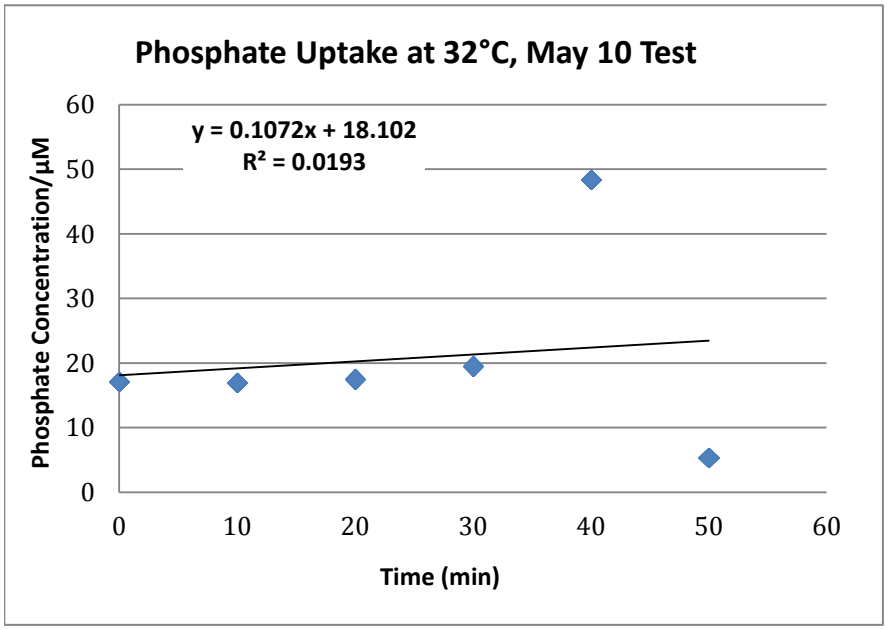
Could it be that *S. cerevisiae*'s capacity for phosphate absorption is influenced by the medium's temperature? It is indeed well known, in cookery and baking, that warmish conditions are required for yeast to « do its bidding ». It was this fact that prompted us into further researching the question.

Yeast develops most rapidly at 25-30°C[2] and cellular destruction begins at around 50°C. Furthermore, at near freezing temperatures the fungi's development almost stops. Many experiments have already been carried out with *S. cerevisiae* and the temperatures employed typically vary between 27 and 40°C.[3]

May 10, 2013 test at T = 32°C			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	0.611	17.08997
10	10	0.607	16.95156
20	20	0.621	17.43599
30	30	0.681	19.51211
40	40	1.515	48.37024
50	50	0.271[1]	5.32526
May 15, 2013 test at T=32°C			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	1.588	50.896
10	10	1.623	52.107
20	20	1.526	48.751
30	30	1.635	52.522
40	40	1.707	55.014
50	50	2.146	70.204

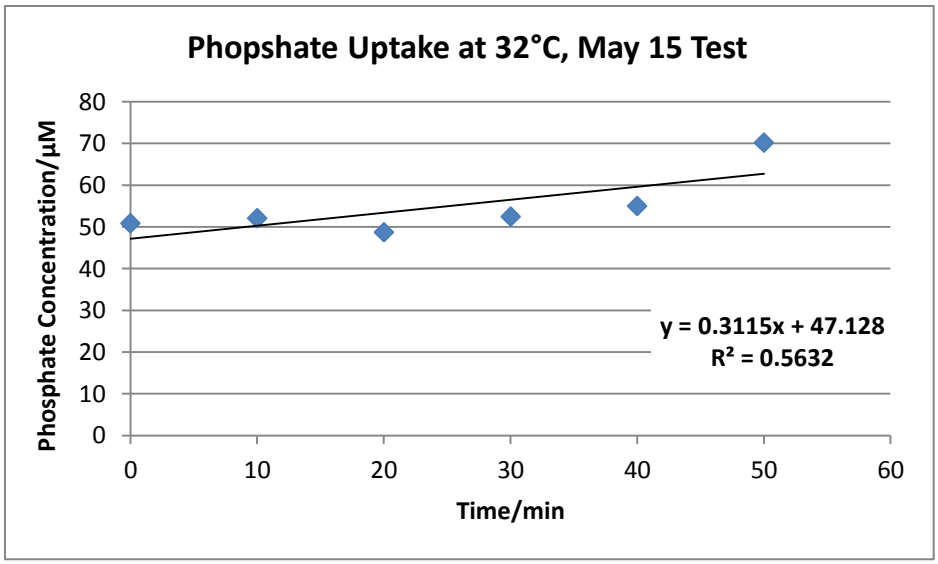
In this method, then, the "independent variable" is the temperature, the dependent one the absorption rate and an example of a controlled variable is the time span during which the phosphate solution was exposed to the uptaking *fungi*.

As in the other approaches, we mirrored almost exactly the procedure given for part 3 by the SOTM Task 2 instructions. But while the Sodium-Phosphate-Buffer in part 3 and in the other approaches of part 4 was kept at T = 22°C, here it was heated in a special oven or incubator at T = 32°C. 20 seconds prior to each extraction of the 300µl aliquot the buffer was taken out and blended with a magnetic stirrer. The sample was then centrifuged for 1min at 4000RCF like the rest and the continuation of the experiment is again identical to part 3.



We started out by doing only 1 set of 6 measurements for this part at 32°C. We planned to do other tests at different temperatures. We only had, though, one oven accurate enough so we decided to carry out each series of tests one by one, starting at 32°C before going on, another day, to other figures. As it happened, the results we got at our first try were poor so we had to repeat the operation at 32°C.

[1] Liquid too clear with "packets" of green matter floating about, clearly a "misfire"!
[2] Wikipedia entry for yeast, in French. Retrieved May 13, 2013 from http://fr.wikipedia.org/wiki/Levure
[3] Article on sciencedirect retrieved May 13, 2013 from http://www.sciencedirect.com/science/article/pii/0014579387808864



Both the charts display the same incoherency: if one is to believe them, at 32°C yeast would actually do the exact reverse of uptaking phosphate, *viz*. rejecting it! However, a swift look at the R-squared values of the two graphs, respectively ~0.02 (appallingly low!) and ~0.57 (almost 30 times better than 0.02 but still far from being trustworthy), convinces us that the chances they are wrong are infinitely higher.

Looking at their formulas reveals to what extent the data varies: the May 10 graph trendline starts at a concentration of ~18.1 µM at 0min. May 15's trendline displays for the corresponding point ~47.1 µM. After comparison with the part 3 chart and analysing the difference of the two R-squared values, we can safely say that May 15 is closer to the "truth". Then, of course, things go downhill, as a manner of speech, or "uphill," literally. The two last results for May 10 are true "Frankensteins." The last of the ghastly pair could have been omitted from the graph as we observed problems with the solution prior to measurement, we decided to include it anyway to illustrate with chilling honesty what bad results can look like. The good side is the >3000% increase in the R-squared ratio from May 10 to May 15, suggesting genuine improvement. The in-depth analysis of our methodical and procedure mistakes continues in the discussion.

Discussion 2/3 (continued)

That some in our class be kept in the dark wasn't inevitable, rather a big, big mistake. Living in the 21th century with the internet and social media at the tip of our fingertips, literally, there isn't any excuse. Every time a group finished an experimental session, it should have briefed the others, through the internet and/or in person, on exactly what happened and why. Tips concerning the handling of the new material should have been shared and discussed more thoroughly, information distributed more forcefully, translation of the instructions to French executed more systematically. All this was done, but to a small and insufficient extent. A stronger, better defined leadership would have been essential for this. Often the persons in charge for various aspects of the project changed over time, some acquiring and others losing influence and responsibilities. It was thus hard to advance in a coherent, structured manner.

Time management, always a major challenge, proved itself to be also a serious hazard. We fell early on behind schedule despite our best efforts; mainly because we had to restart part 2 two or three times to get a good calibration curve. Part 3 took more time than predicted, on top of yielding unfortunate results. The massive part 4 had yet to be done, and when its turn came May 17 was already closing dangerously in. A fair deal of research was required for the "design your experiment" step of each approach. As the charts and tables clearly demonstrate, every method was carried out two times. When, to our dismay, we realized the second "round" of results was just as botched as the first, on May 15, we knew we couldn't repeat the whole process again. *Alea iacta est.*

Another main error was failing to "anticipate the collection of sufficient data." We were too engrossed in the immediate tasks at hand and hadn't given the matter as much forethought as it deserved. This indicates, again, a muddled state of mind spawned by a certain amount of collective confusion as to what exactly it was each of us individuals had to do. This brought forth an element of improvisation, in itself nothing bad. But when combined with deficiencies in communication, people's activities, especially in research and translation, tended to overlap, entailing an avoidable loss of productivity.

The nature of many experiments requiring, as said before, much less people than the class total caused serious issues. To avoid people twiddling their thumbs for want of work, we decided early on to diversify our activities into different, more artistic activities. We hoped they would make our report more original, attractive and interesting, as well as boost our morale and affirm our identity as a visual arts class fascinated by science. One particularly gifted student was assigned to creating a mascot representing the 2M11, another one to make a short, introductory video. The video was cancelled near the end for want of time as we got bogged down in the experiments.

Part 4, pH Approach

Here we will strive to "enhance the efficiency of the phosphate-uptake" by exposing the *S. cerevisiae* to differing pH environments. In part 3, the yeast was blended with Sodium-Phosphate-Buffer at pH 6.3. Will the fungi really uptake phosphate more or less efficiently at, say, pH 5.5 or 7.2? Probably yes. Two Dutch scientists wrote in 1977 that "both the maximum rate of phosphate uptake and the K_m [the concentration that causes half maximal velocity of uptake] depend upon the pH of the medium in a complex way".[1] Also, "the effect of medium pH upon the maximum rate of uptake is mainly indirect and is correlated with changes in cell pH".[1] What the pair of Hollanders wants to get at is that changes in medium pH do have reverberations on phosphate uptake, whence the relevance of modifying it.

Like for the rest of part 4, the entirety of this method is adapted step by step from that given in the instructions for part 3. The exception to the rule, of course, is the independent variable we chose, after research, to manipulate – in this case the pH. 6.3 "normally", here it is 5.9. Our school's laboratory operator, Mr B. Mathez-Neels, kindly took it upon him to prepare for us the pH 5.9 Sodium-Phosphate-Buffer. He managed to do this by using the "Henderson-Hasselbalch (or –bach)" equation: $\mathrm{pH} = \mathrm{pKa} + \log\left\{\frac{(\text{proton acceptor})}{\text{proton donor}}\right\}$[2], Ka being "*the ionization constant for the partially ionized acid.*"[3] As always, a magnetic stirrer was utilized for blending the buffer and yeast together.

May 10, 2013 test at pH 5.9			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	0.631	17.78201
10	10	1.159	36.0519
20	20	0.637	17.98962
30	30	0.629	17.7128
40	40	0.634	17.88581
50	50	0.649	18.40484
May 15, 2013 test at pH 5.9			
EPs	**Time/min**	**Absorbance (595nm)**	**Concen./µM**
0	0	1.664	53.5259516
10	10	1.618	51.9342561
20	20	1.371	43.3875433
30	30	1.544	49.3737024
40	40	1.642	52.7647059
50	50	1.494	47.6435986

The pH experiment table and charts present us with more mediocre data. Even if the trendlines, this time, display a "downhill" tendency, a welcome change after the "uphills" of the glucose and temperature graphs, they cannot be trusted. In effect, the May 10 one, R-squared value ~0.14, is far from being worthy of our confidence. ~0.09, for May 15, is even worse. The concentration values for the May 10 test are anything but dubious: with the exception of the 10min they all stagnate at around 17 or 18µM, way too low. In this respect those of May 15, scoring between 53 and 47 µM, are better when compared with the data of other experiments (parts 3, 4/glucose and 4/temperature). Unfortunately, this is as far as comparison of the results takes us, they are too unreliable for more serious conclusions and deductions.

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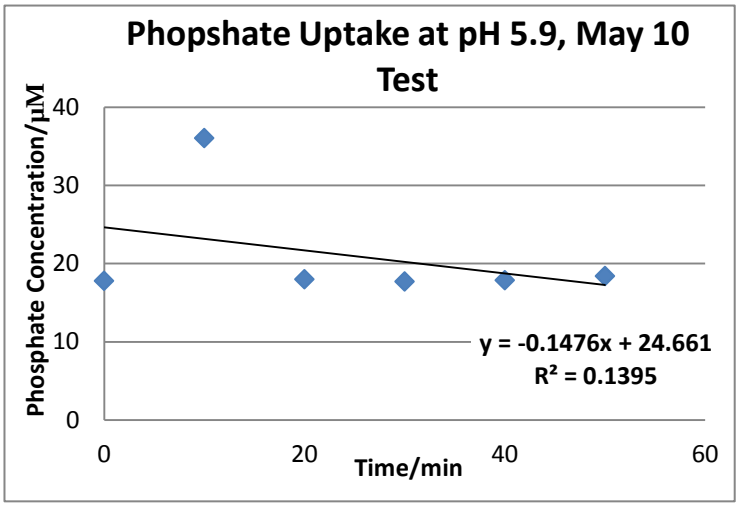
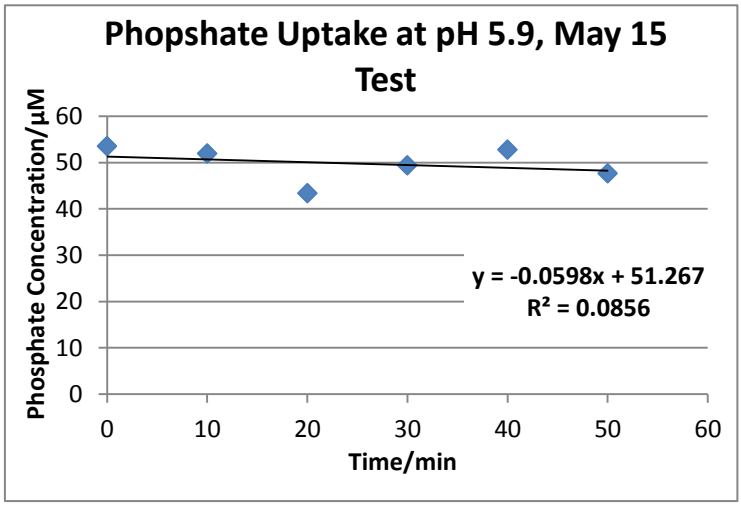
[1] Borst-Pauwels G. W. F. H., *et al.* 1977. *Effect of the Medium pH and the cell pH upon the kinetical parameters of phosphate uptake by yeast*. Retrieved May 12, 2013 from http://www.sciencedirect.com/science/article/pii/0005273677903418.

[2] From *Biochemistry 1*,p5. University of West Florida. PDF file retrieved May 17, 2013 from http://www.google.ch/url?sa=t&rct=j&q=ph%3Dpka%2Blog%E2%81%A1%7B((proton%20acceptor))%2F(proton%20donor)%7D&source=web&cd=1&ved=0CCsQFjAA&url=http%3A%2F%2Fuwf.edu%2Fdcdavis%2Fbiochem1%2Fab%2Fab.pdf&ei=csWVUeG9OYO44ASB8IDwBw&usg=AFQjCNHwZHv43HJJ9-9t3KaDsQWRLUsDZQ

[3] "Meaning of pKa" on the Q&A section of the website *Newton*. Retrieved May 17, 2013 from http://www.newton.dep.anl.gov/askasci/chem03/chem03341.htm





Discussion 3/3

In this last piece of the final discussion, and after having bombarded the reader with enough "gestalt" self-questioning, it is time to proceed to precise causes which, we believe, may have given birth to many of our blunders.

Contamination managed to occur too often in the course of this project and it definitively indicates amateurish scientific practices. Very early on, during our first session in the "lab", the D-water got contaminated by Malachitgreen. This was probably caused by mishandling of the pipets, namely not changing the end-piece of the pipet between the extractions of two different solutions. Maybe we were fortunate that it was Malachitgreen; we immediately saw the D-Water put on a light blue tint and stopped using it. Something else might have gone unnoticed for much longer. The wasted D-Water was replaced by other extra pure water used in our canton's laboratories for the same purposes. Also, a tube of Sodium-Phosphate-Buffer was wasted in the beginning due to mishandling. Here too more of it was produced by our school's lab operator. It may be inferred that these changes from products given to us by Simply Science to others, made by different institutions, could have affected our results in some way or the other. Still, theoretically the solutions should have been the same and they were all made by qualified professionals. Even if slight variations did exist they could never have spoilt our results on such a big scale all by themselves. We cannot verify this now for want of time and so this must stay at the hypothetical stage.

For some of the wackier data samples of part 4, we even thought that on one or two occasions the volumes of the solutions were different. This was only noticed by two of us and none of the pair are 100% sure this happened, probably more like 50% positive. Admitting this was really the case, it would mean serious pipetting weakness, because the material we received from Simply Science was extremely good and precise. We did nonetheless quite well in the Part 2 calibration curve, meaning at least a healthy portion of the class fully mastered the precision pipets, so this comment should be taken with a pinch of salt.

Another likely explanation is that as we usually took out our yeast cubes of the fridge where they were stored just moments before starting the experiments, they were cold (T = 5°C). Anyone having ever learnt to bake bread knows the dough, once blended with the fungi, must "rest" in a warm place for the fungi to ferment effectively. Going against this is our usage of "pelleting" the yeast into small granules by hand (covered in glove) for proper measurement and more efficient blending. The yeast so treated was heated by friction and by the body temperature which emanated from the blue latex-covered skin.

So the true answer is still elusive, like the larger "Truth" Mohandas Gandhi so often thought, talked and wrote about. But elusiveness has little or no place in Science, where one must often strive for ages to reach reliability. One of our teachers told us how a friend of his, a researcher, reacted when he was told about our lack of success in our measurements. "No wonder, I had to spend two whole years to get usable data!"

What have these two months of Science On The Move been for us? Great challenges, new and exciting worlds discovered, many memorable moments and a lot of lessons to be learnt. This task enabled us to better imagine the thousands of hours of painstaking work behind every scientist, the almost superhuman patience and rigour behind every discovery, every small or giant "leap for mankind." Above all else, we got the opportunity to learn more about ourselves – and each other – in the process; to realize how unity, cohesiveness and teamwork are the essential elements for any kind of progress.

Activity List

Phosphate uptake by yeast cells

Bernard Mathez-Neels
Preparation of the solutions

Teachers:
David Wintgens
Alexandra Soldevilla
Philippe Devaud
Stoyan Grenacher

Global Studies
All

Gyan Kumar & Terry Vogelsang
(Person in charge of the experiments)

Phosphate uptake by yeast cells

Calibration
Results Analysis
Photographs
Serena Monterastelli
Nathalie Benoit
Loulou Assad
Antoine Raffner

Amandine Voillat
Demily Vuille
Sven Abplanalp
Photographs
Results Analysis

Improve Phosphate uptake

Experiment 1: pH
Naomi Friche
Loriane Kjelsberg
Camille Horowicz
Photographs
Results Analysis

Experiment 2: Temperature
Marianne Fatton
Aurélie Guillaume-Gentil
Photographs
Results Analysis

Experiment 3: Glucose
Lally Quenet
Jade Rimle
Sabina Dalipova
Photographs
Results Analysis

Justinas Sukaitis
(Advanced research section manager)

Maïté Amstutz
Béryl Alzetta
Julie Buisson
Marie Béguin
Dorian Giauque

Studying Phosphate absorption
Logo of the 2M11
Studying about uses of Phosphate
Studying yeast cells role
Studying about eutrophication
Graphs and writing
Hypothesis researches

Two very different worlds : the intensity of the laboratory and the long quest of research.

Eager beavers !