Scenario D – A Grape Gene Expression Study

Background:

The food industry is one of the largest industries throughout the world. It is an industry that is constantly moving forward and looking for ways to improve. Recent technology has lead to large advances in the areas of agriculture. Some of the latest technology looks at the genomes of plants and animals with the hopes of understanding gene function. This should allow farmers to grow and care for these organisms in the best conditions possible. The idea behind this is to maximize the growth and production of the organism to help productivity, increasing profits while decreasing the time put into the procedure.

One of the newest users of this technology are the grape growers. Grapes are a large market, primarily in the area of fruit grapes and grapes used in wine making. Learning more about the genomes of grapes, as well as their gene expression has a huge amount of potential and a big market. If you could determine the best conditions for growing the different types of grapes, you could produce the perfect grape needed for the specific food use without any of the guess work that usually goes on.

You are part of a research group assigned to study gene expression in wine grapes at different conditions. You are looking for the prefect way to manipulate the environmental conditions of the grape plant in order to grow the grape with the precise acid and sugar content needed for producing wine. Your group decides they must be able to analyze as much gene activity as possible at the same time. You turn to the use of the newest GeneChip microarray – the *Vinis vitifera* Genome Array. The *Vinis vinifera* Genome Array covers the entire genome of the grape and can be used to tell which gene expression pattern produces the "perfect" grape.

The *Vitis vinifera* needs hot dry summers and cool winters. Your group decides to test the best conditions during the winter since less information is known about these conditions. The grapes were all grown in the same conditions during the summer, but when winter came, the conditions of the grapes were varied, you did tests, and you extracted total mRNA during that time. After the end of the growing year, the grapes were harvested and final tests were made to determine if the had the precise chemistry needed to produce the best wine.

In terms of the genes that you decided to study, you did some research and decided to focus on 6 genes known to be involved in the biochemical pathways responsible for the acid and sugar content of the grape. For simplicities sake, we will just number the genes from 1 to 6.

The conditions studies were: soil pH, temperature, and water amount. You manipulate the soil pH by adding lime and a weak acid, the water through irrigation, and the temperature by growing the plants in a separate enclosed green houses. This is just a preliminary study, so you group each condition in to high, medium and low. This should help you narrow it down to the perfect conditions for further studies. Your objective is to

help growers determine how to best manipulate the pH and water amount during the changes in temperature.

Results:

Grape growers rate the grapes on a 1 to 5 scale depending on how well the sugar and acid content of the grapes fit with what is needed. Here is the scale"

Rating	Description
5	the "perfect" grape / has all qualities needed for wine production
4	- "great" grape with perfect acid content but slightly off sugar content (or vice versa) / may need to add in some 5 grapes
3	"good" grape with slightly off sugar and acid content / will need add in some 5 grapes before production
2	"poor" grapes with sugar and / or acid contents off what is needed / can only be used to produce low quality wine
1	- the "terrible" grape / unusable on any levels

You grow the grapes in three different temperatures (8 ^{0}C, 12 ^{0}C, and 16 ^{0}C). For each temperature group, you try combinations of low, medium, and high soil pH, and water amount. The low and high amounts are not extremes, just above or below the medium.

Here are the levels for each test:

Low Temperature = 8 ^{0}C	Low pH = 5	Low Water = 4 dm
Medium Temperature = 12 ^{0}C	Medium pH = 7	Medium Water = 14 dm
High Temperature = 16 ^{0}C	High pH = 9	High Water = 24 dm

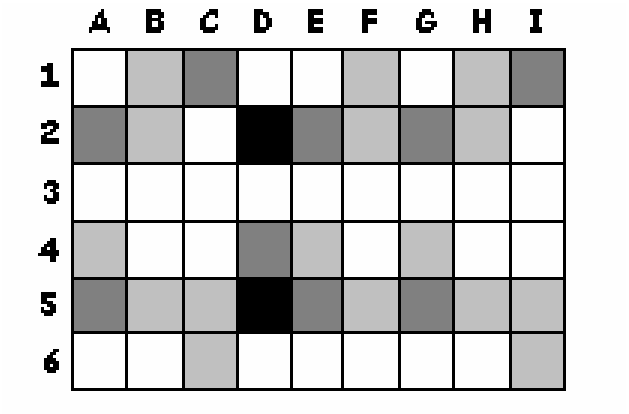
Now, since there are three different levels for each test and if you are trying each combination, then there are 27 different possibilities. Each different test will be given a letter from A to Z and @ to help with organization of the data. Once again, you will group them by the temperature, so there are 9 combinations for each test:

Low Temperature (8 ^{0}C)	Medium Temperature (12 ^{0}C)	High Temperature (16 ^{0}C)
A (low pH, low H2O)	J (low pH, low H2O)	S (low pH, low H2O)
B (low pH, med H2O)	K (low pH, med H2O)	T (low pH, med H2O
C (low pH, high H2O)	L (low pH, high H2O)	U (low pH, high H2O
D (med pH, low H2O)	M (med pH, low H2O)	V (med pH, low H2O)
E (med pH, med H2O)	N (med pH, med H2O)	W (med pH, med H2O)
F (med pH, high H2O)	O (med pH, high H2O)	X (med pH, high H2O)
G (high pH, low H2O)	P (high pH, low H2O)	Y (high pH, low H2O)
H (high pH, med H2O)	Q (high pH, med H2O)	Z (high pH, med H2O)
I (high pH, high H2O)	R (high pH, high H2O)	@ (high pH, high H2O)

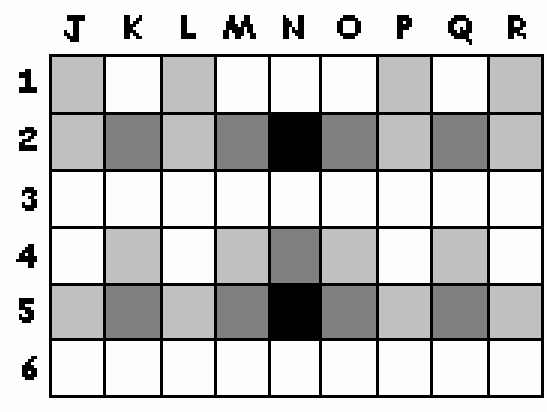
The results of the experiment are to look at the gene expression for genes #1-6 at the different conditions. Do not forget that the Gene Expression microarray can not only tell you what genes are "on" or "off", but can also be quantitative and tell you at what level is the gene "on". The color scheme is fairly straight forward. A black feature means the gene is highly expressed at the conditions. A dark grey feature means the gene is expressed at a medium level. A light grey feature means the gene is expressed at a low level. A white feature means the gene is not expressed at that condition.

Here are the array outputs under each condition:

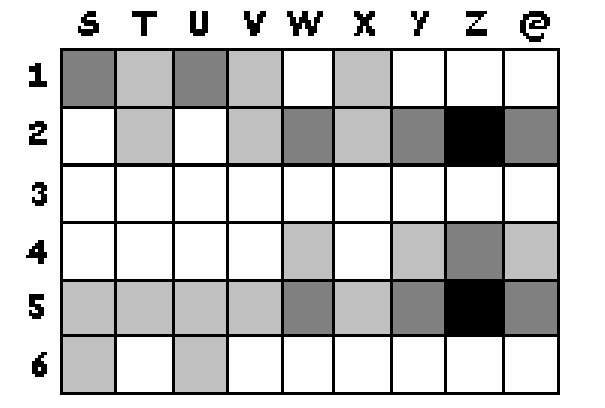
Low Temperature:



Medium Temperature:



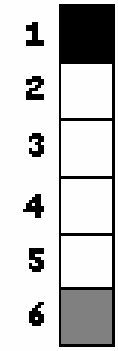
High Temperature:



At the end of the study you were able to obtain the quality rating of each grape at each condition. Here are the results:

Grape	Rating	Grape	Rating
A	4	O	4
B	3	P	3
C	2	Q	4
D	5	R	3
E	4	S	2
F	3	T	3
G	4	U	2
H	3	V	3
I	2	W	4
J	3	X	3
K	4	Y	4
L	3	Z	5
M	4	@	4
N	5		

Since none of these conditions gave the poorest quality grape, you were a little worried that you didn't a full comparison. At the last minute, your group was given some very poor quality (1) grapes that you decide to analyze for further information. Here is what the Gene Expression array output looked like:



Directions:

Make some sense of this data! How did the changes in conditions change the gene expression? Which gene expression profile leads to the best quality (5) grapes? Which genes were on when? And how high were the expression levels of each gene? What gene expression profile leads to the other qualities? How can a grape grower use this information to grow the best quality grapes? These are just some of the questions to look into. There are many other aspects to look at. Good luck!

(Hint: You may want to develop some table that allows you to easily compare the expression patterns with each condition and each quality rating)