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Hydrogen Ion Activity
Better ~~Living~~ Viticulture Through Chemistry

Mg Deficiency (Concord)

Acid Soil – Mg and P deficiency – Cab Sauv

Acid Soil – Mg and P deficiency – Riesling

Potassium Deficiency - Concord

Iron Deficiency - Concord

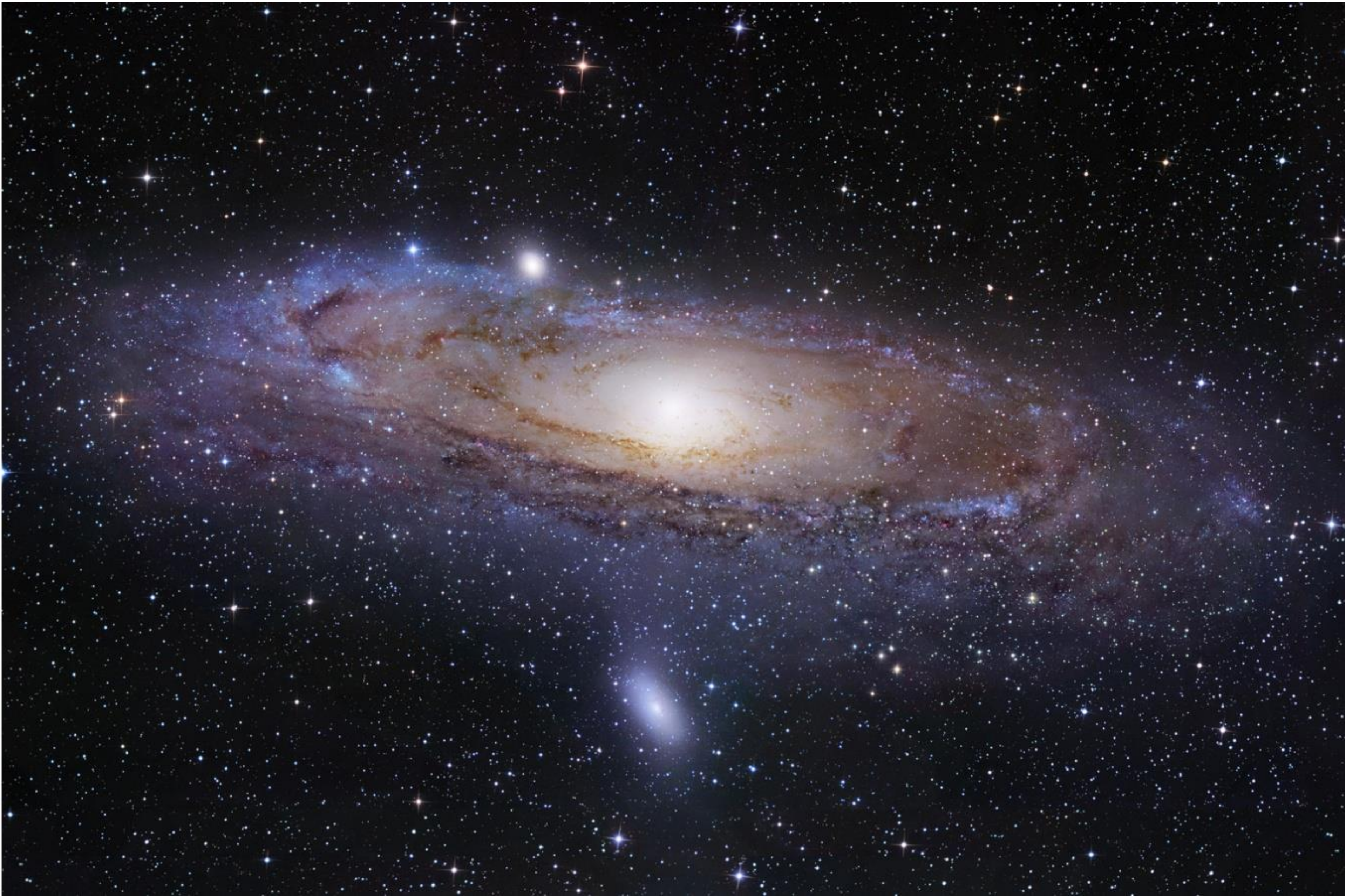
Vineyard Soil pH and Mineral Nutrition

1) Mineral Nutrient Availability: Soil pH

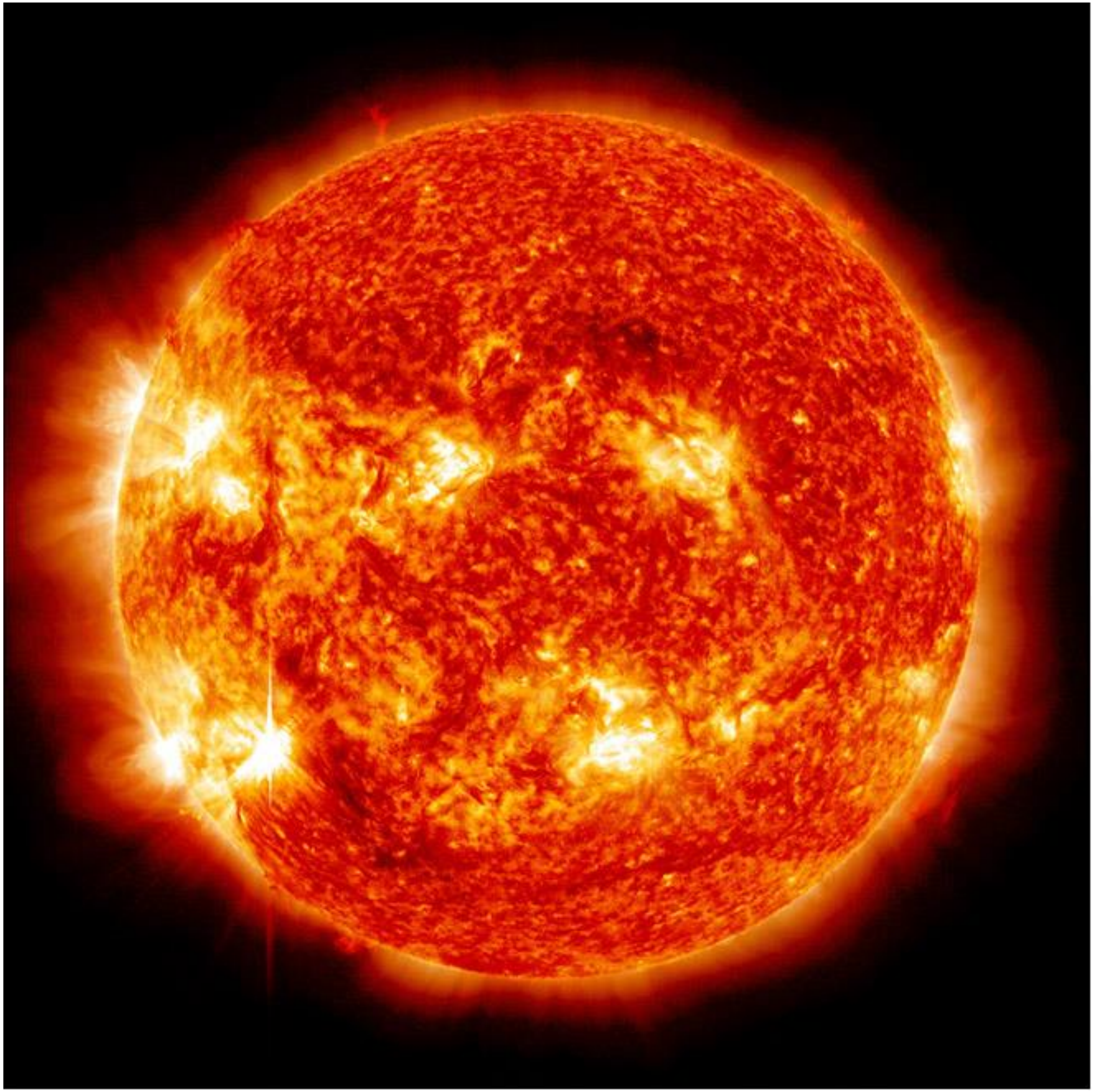
2) Mineral Nutrient Balance: CEC

3) Mineral Nutrient Demand: Management Considerations

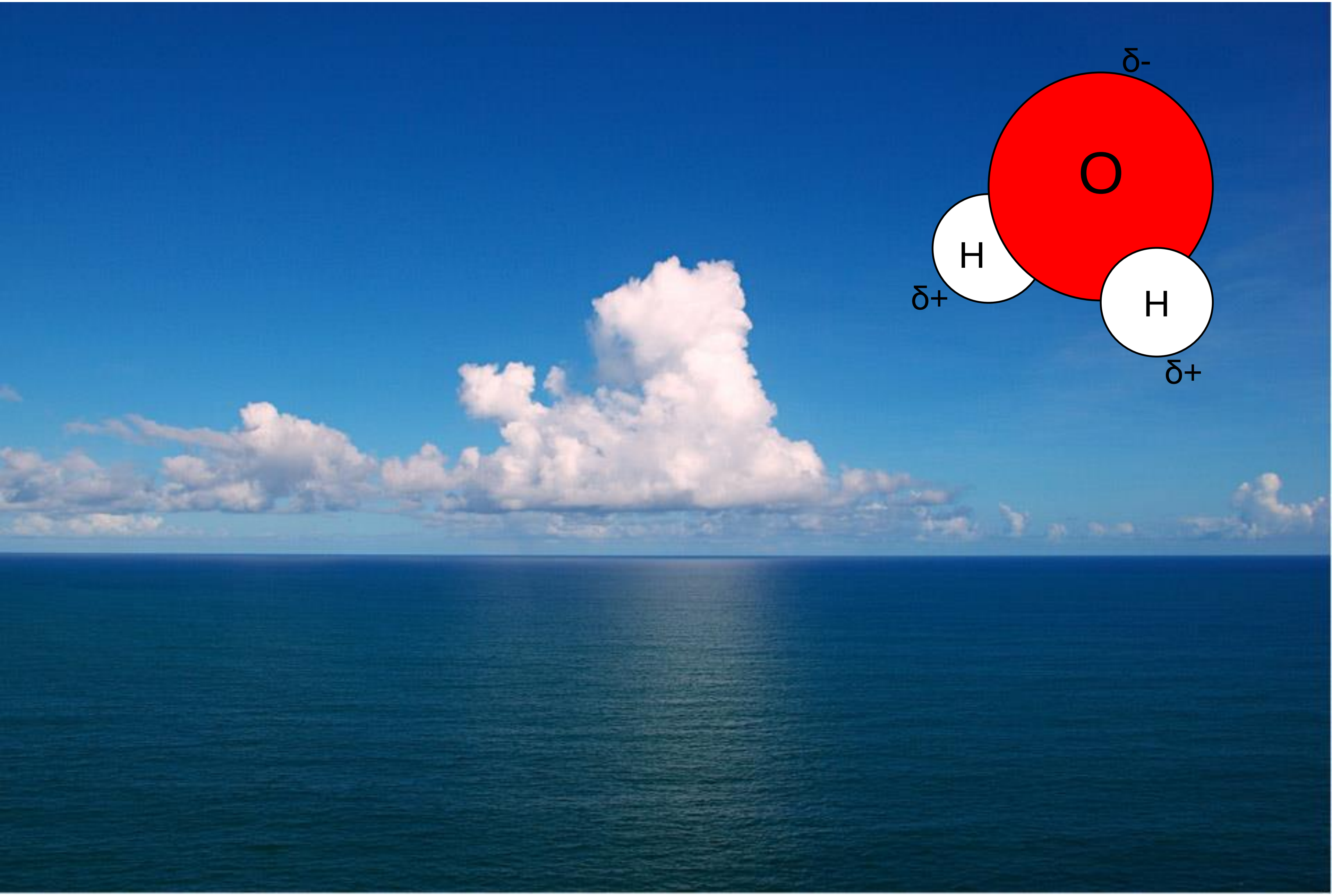
Hydrogen: 90% of the Universe by weight

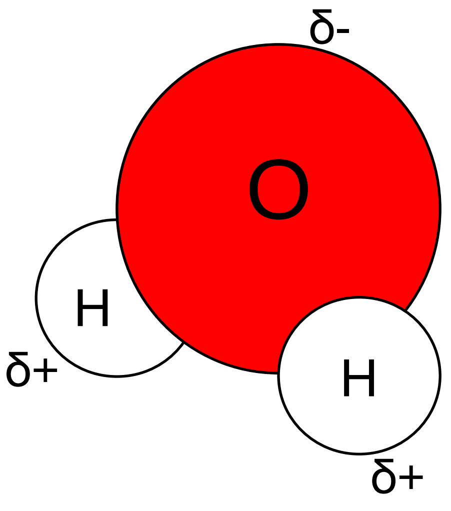


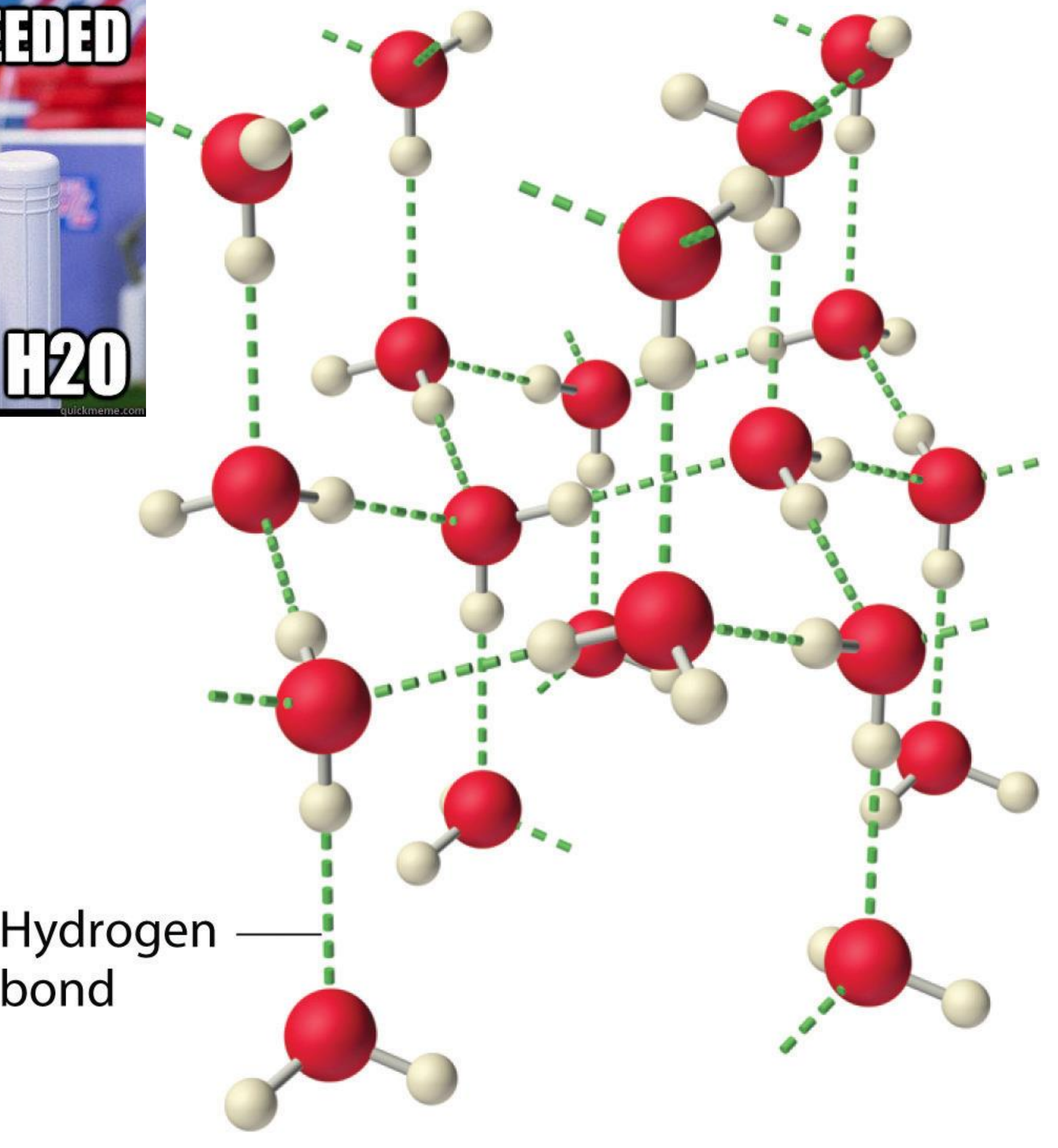
Hydrogen: Most abundant element in the sun (at least for 5 billion more years)



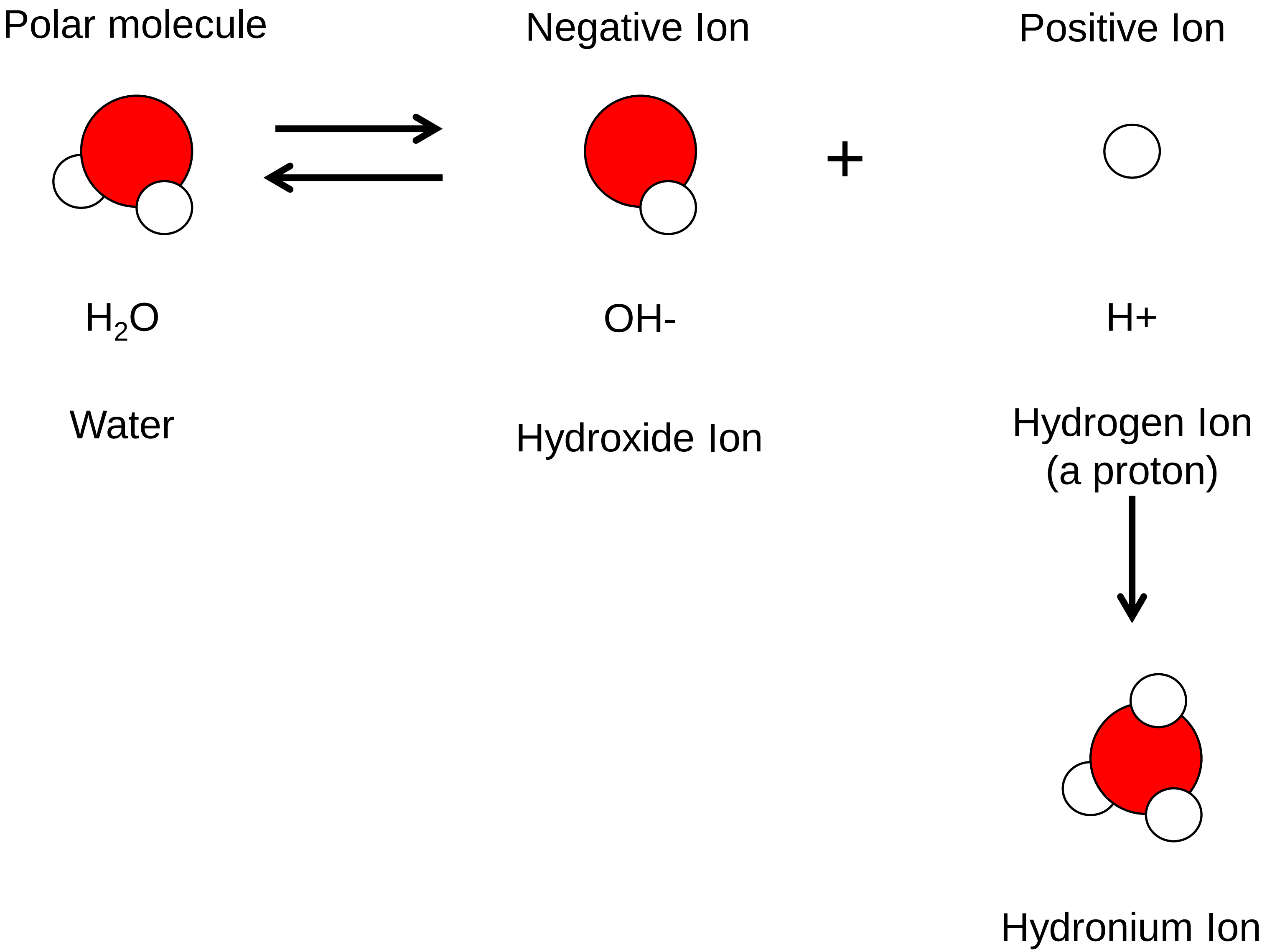
Hydrogen: Can be quite reactive

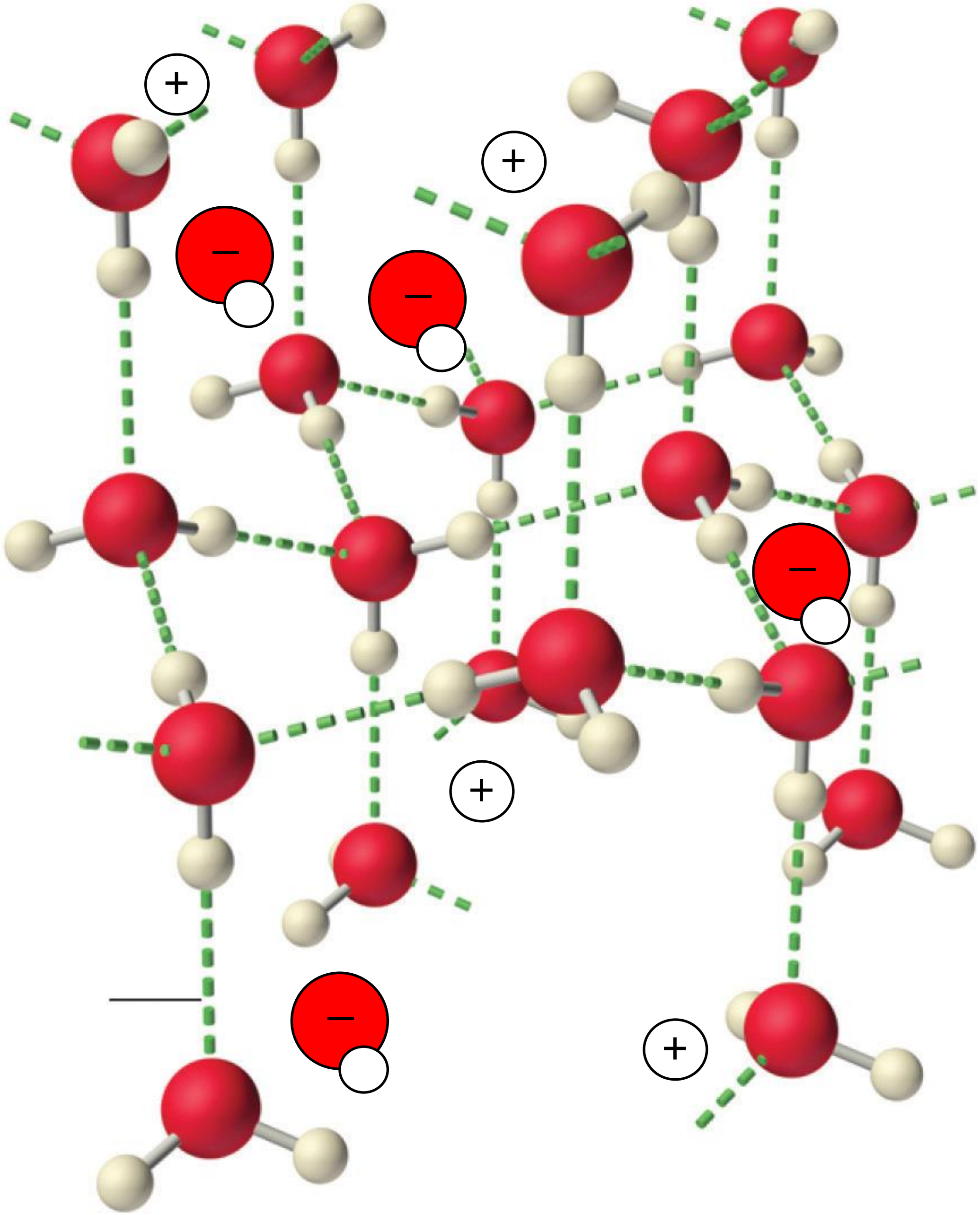

δ-
O
H
δ+
H
δ+





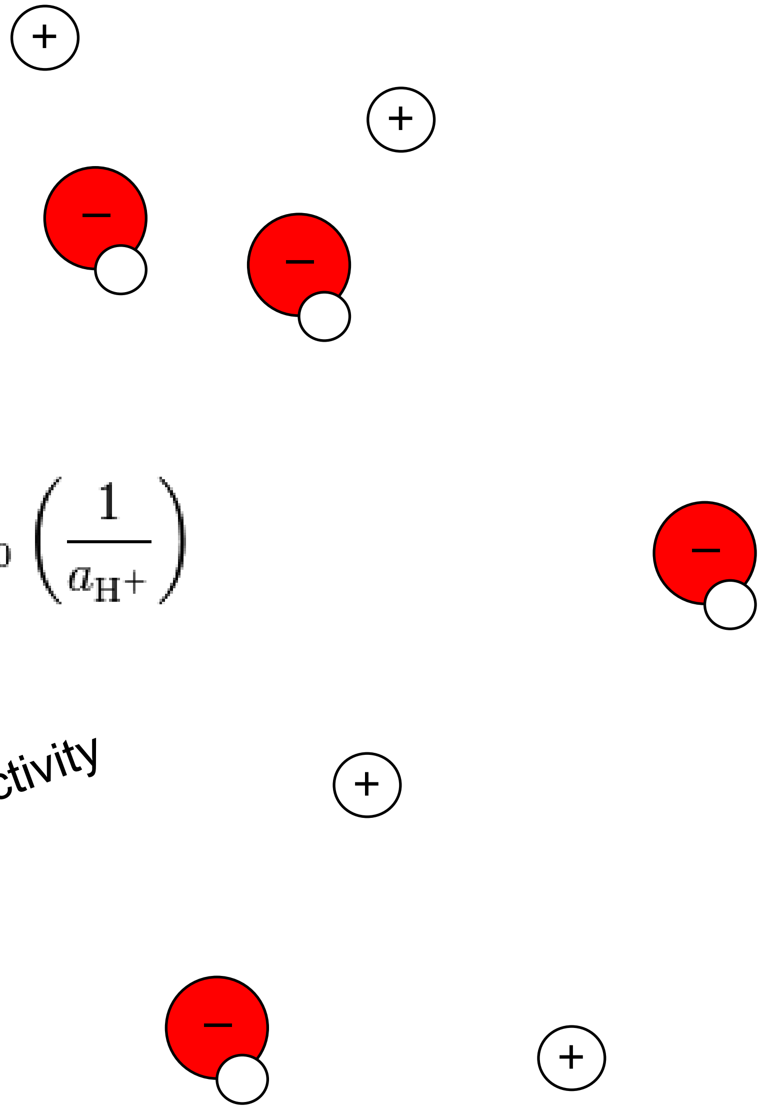
http://images.flatworldknowledge.com/averillfwk/averillfwk-fig11_008.jpg

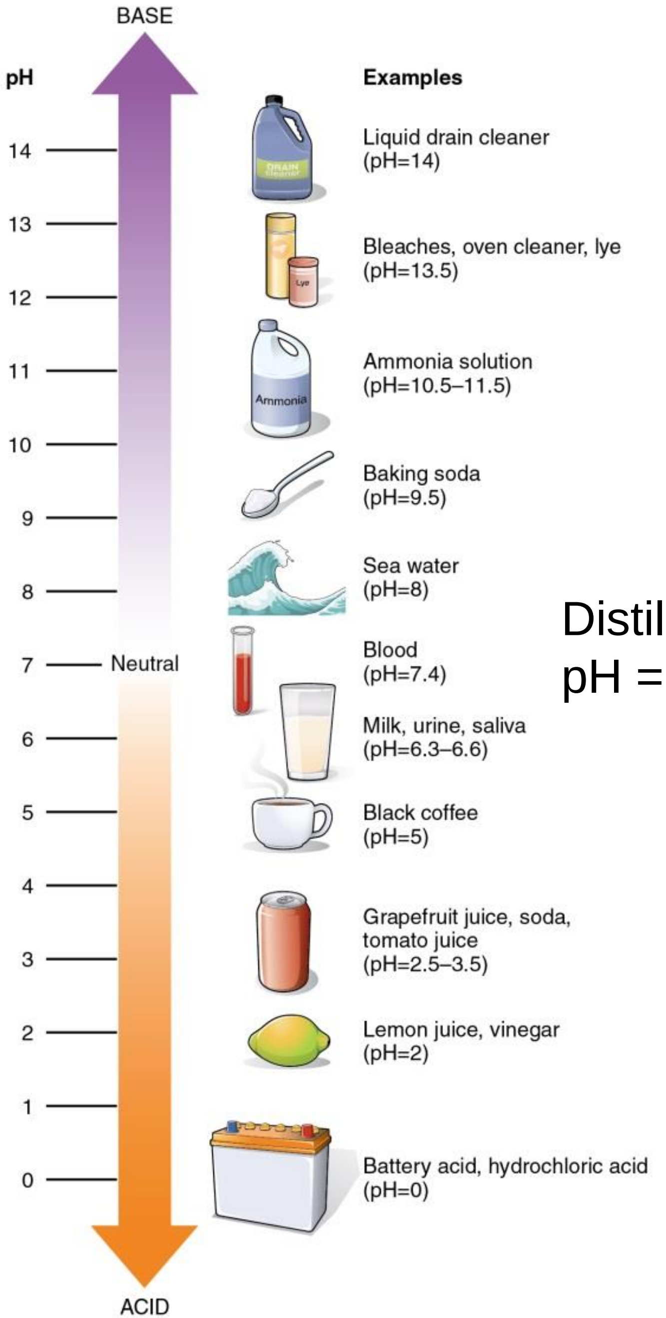

Polar molecule
Negative Ion
Positive Ion
+
H_2O
OH-
H+
Water
Hydroxide Ion
Hydrogen Ion
(a proton)
Hydronium Ion



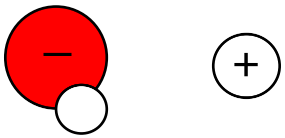
$$\mathrm{pH} = -\log_{10}(a_{\mathrm{H}^+}) = \log_{10}\left(\frac{1}{a_{\mathrm{H}^+}}\right)$$

Hydrogen ion activity

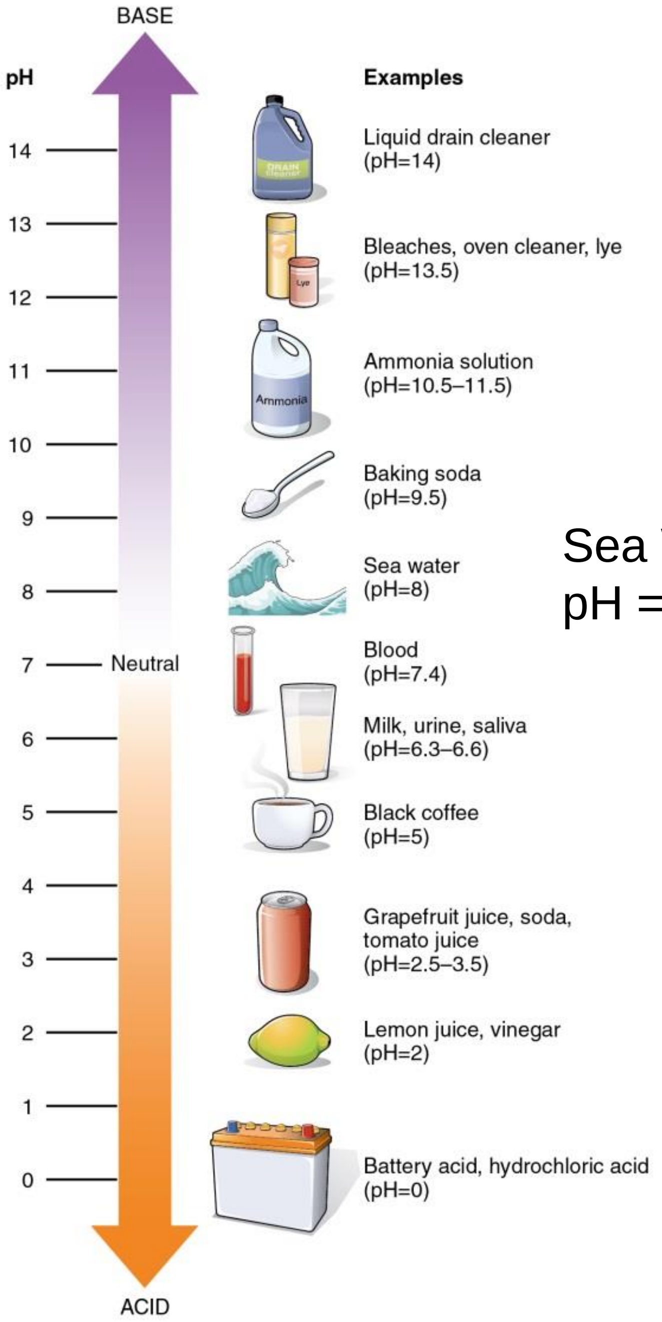




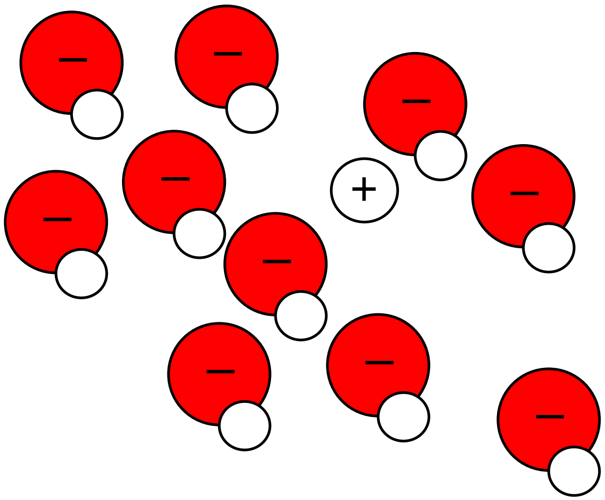
Distilled Water
pH = 7.0



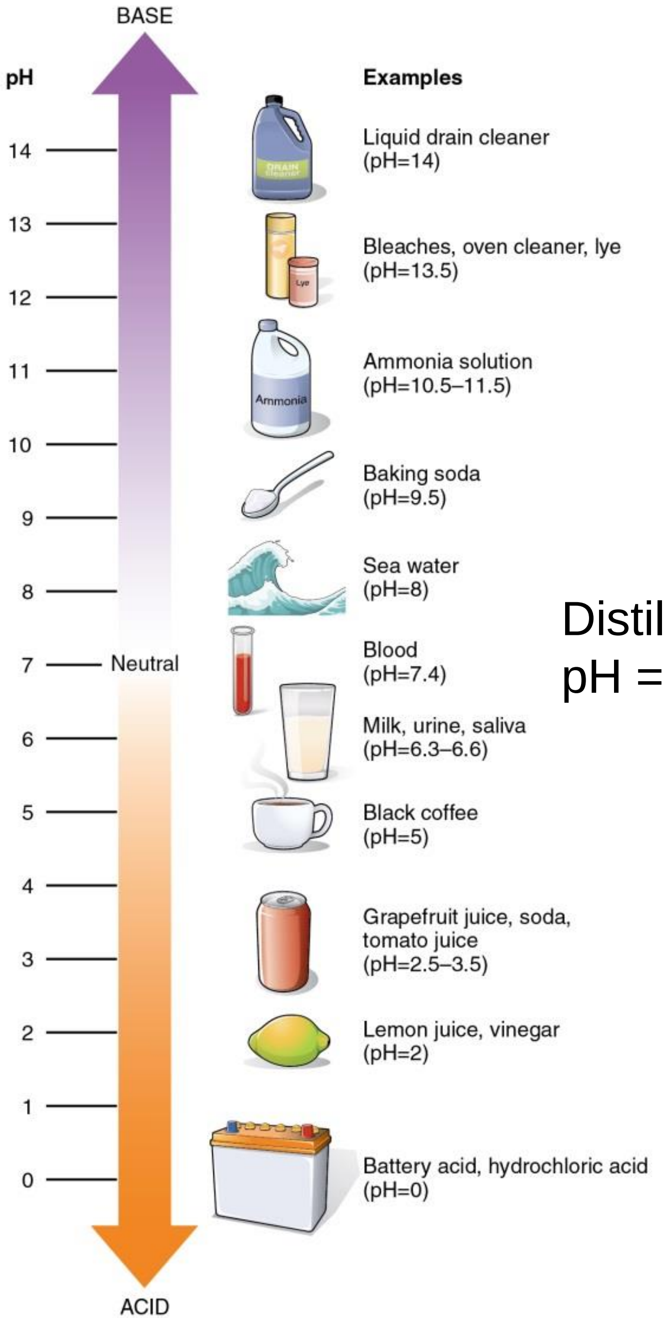
http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg



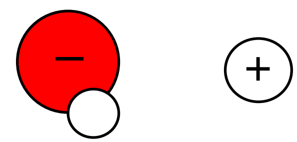
Sea Water
pH = 8.0



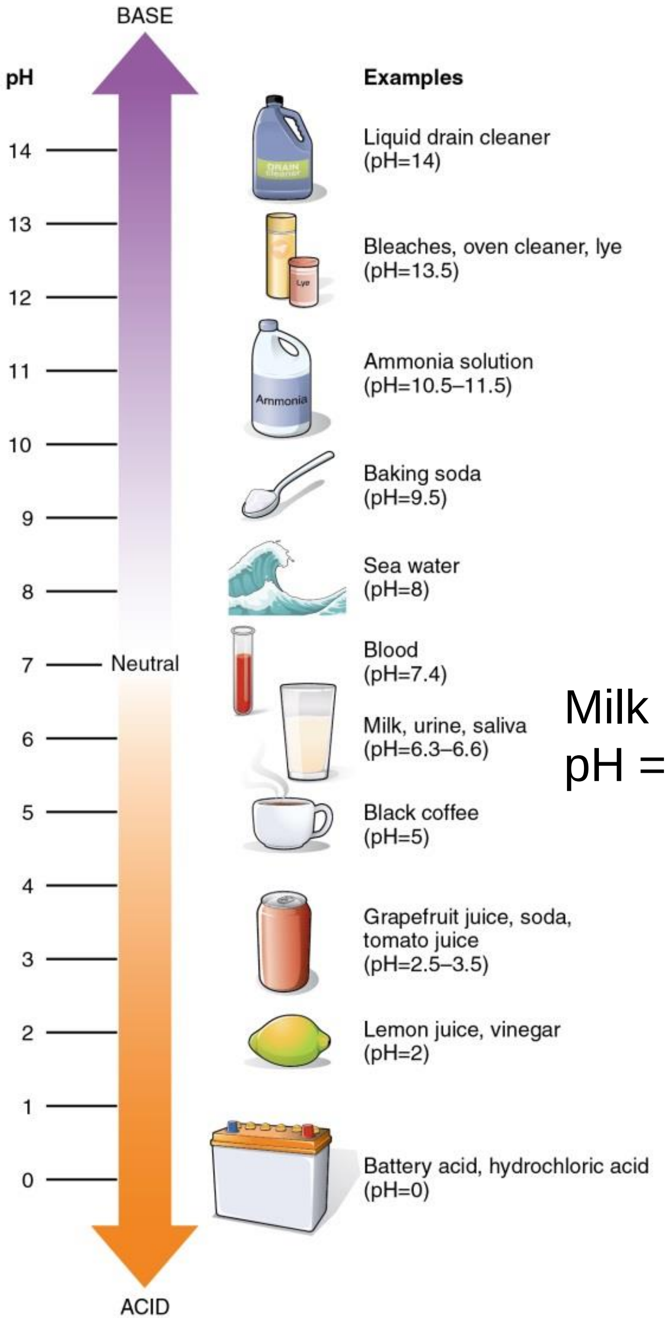
http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg



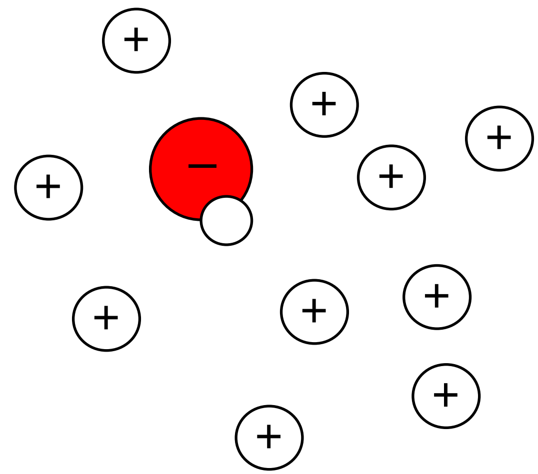
Distilled Water
pH = 7.0



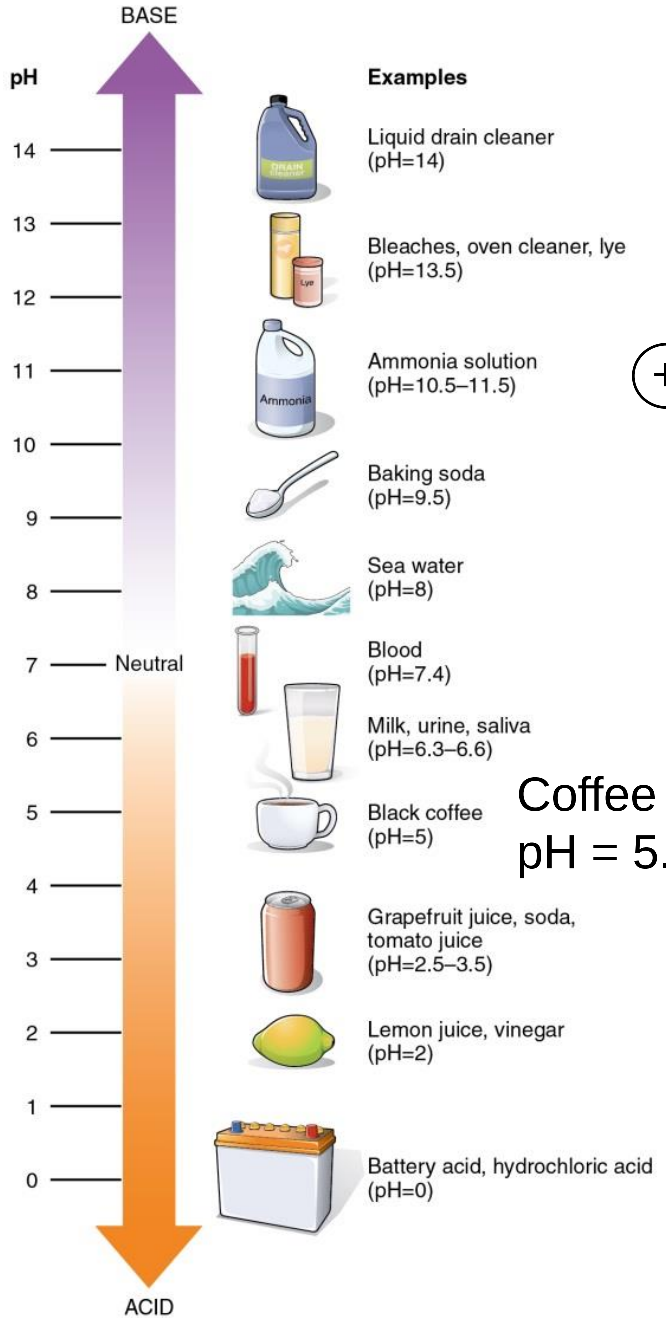
http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg



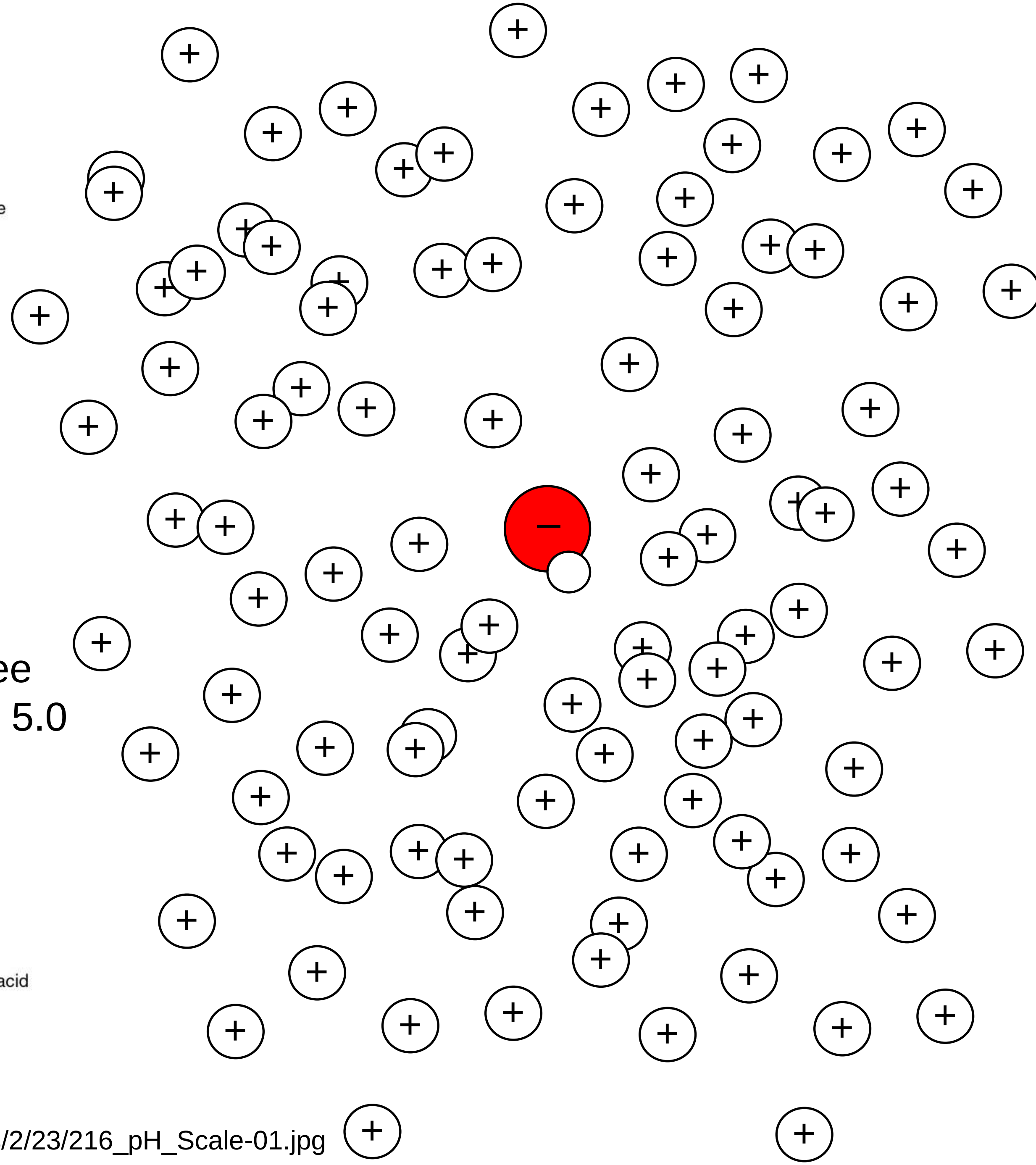
Milk
pH = 6.0



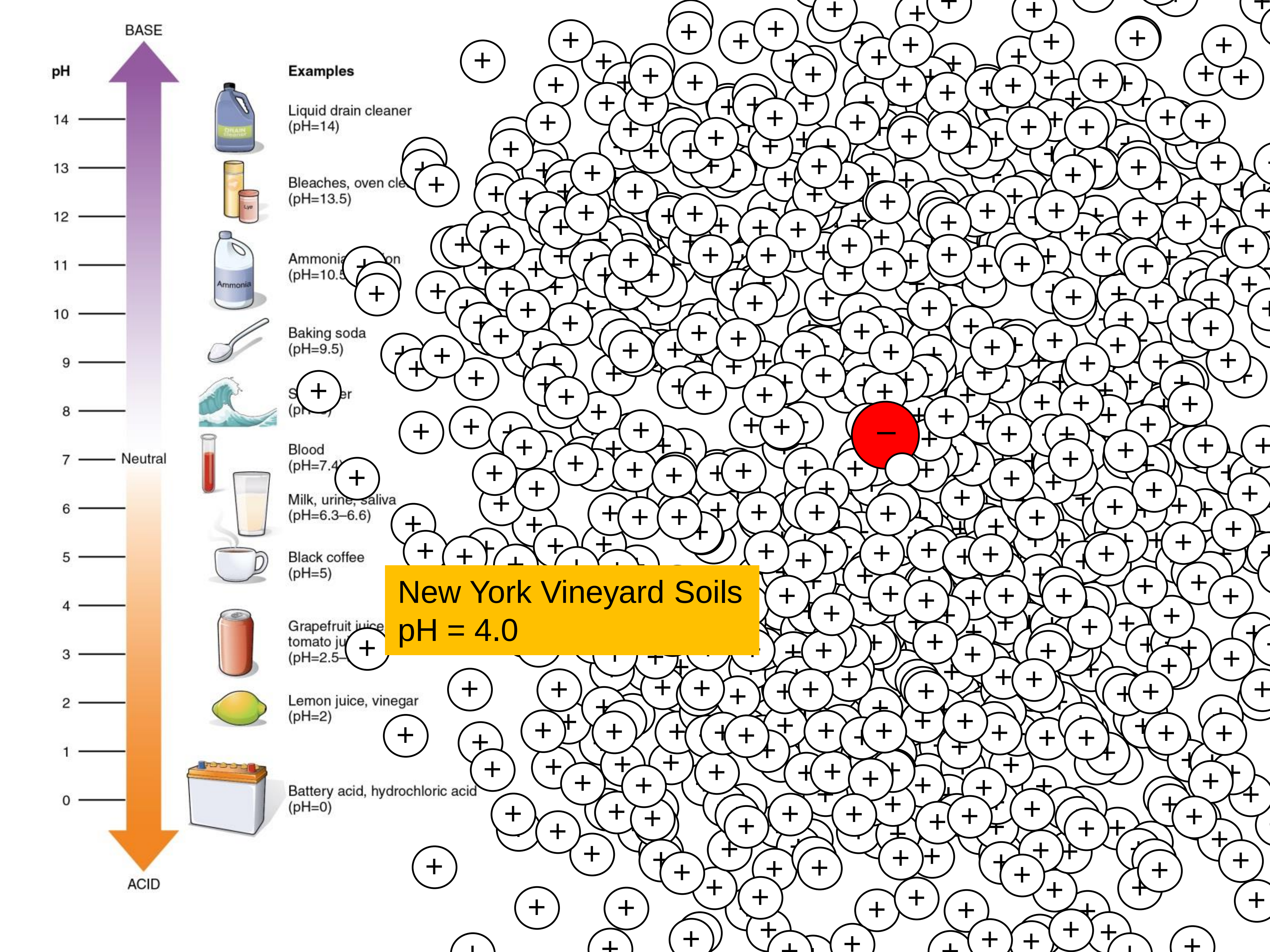
http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg



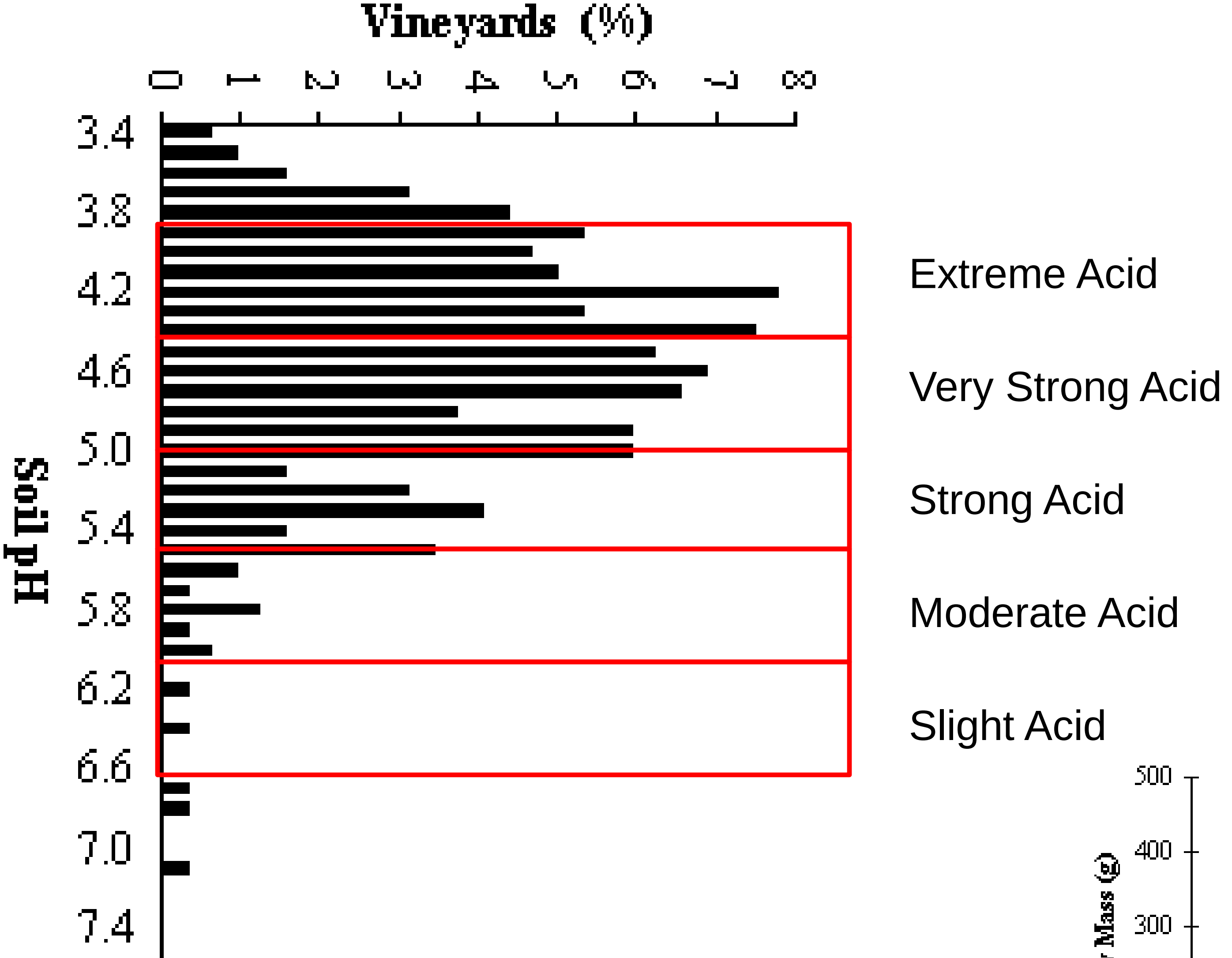
Coffee
pH = 5.0

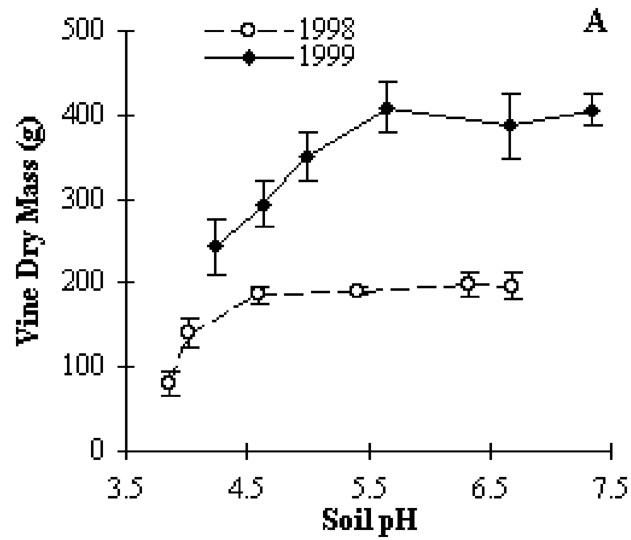


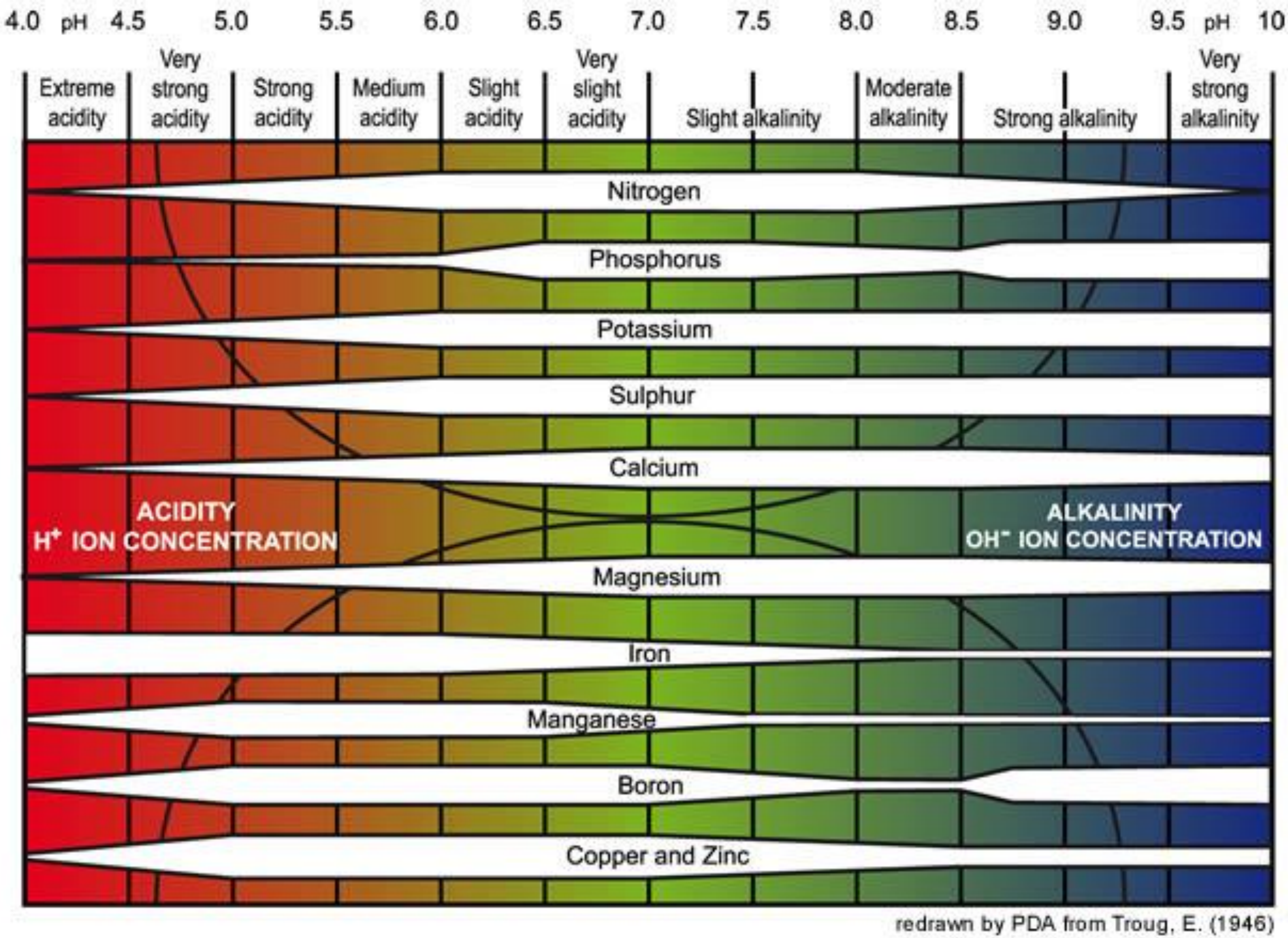
http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg



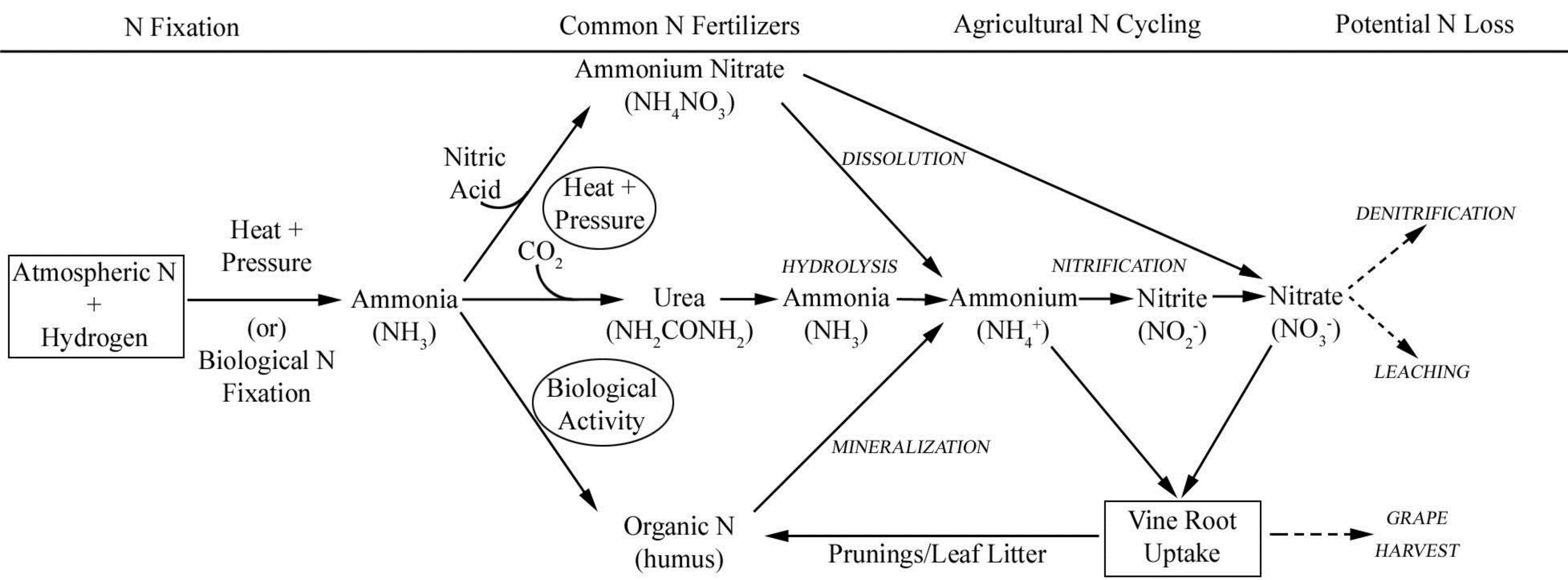
BASE
pH
Examples
14
13
12
11
10
9
8
7
Neutral
6
5
4
3
2
1
0
ACID
Liquid drain cleaner
(pH=14)
(pH=13.5)
Baking soda
(pH=9.5)
Blood
Milk,
(pH=6.3–6.6)
Black coffee
(pH=5)
Lemon juice, vinegar
(pH=2)
Battery acid, hydrochloric acid
(pH=0)
Ammonia
+
–
New York Vineyard Soils
pH = 4.0


Vineyards (%)
0 1 2 3 4 5 6 7 8
3.4
3.8
4.2
4.6
5.0
5.4
5.8
6.2
6.6
7.0
7.4
Soil pH
Extreme Acid
Very Strong Acid
Strong Acid
Moderate Acid
Slight Acid


A
1998
1999
Vine Dry Mass (g)
500
400
300
200
100
0
3.5
4.5
5.5
6.5
7.5
Soil pH



http://www.pda.org.uk/leaflets/24/leaflet24-5.html

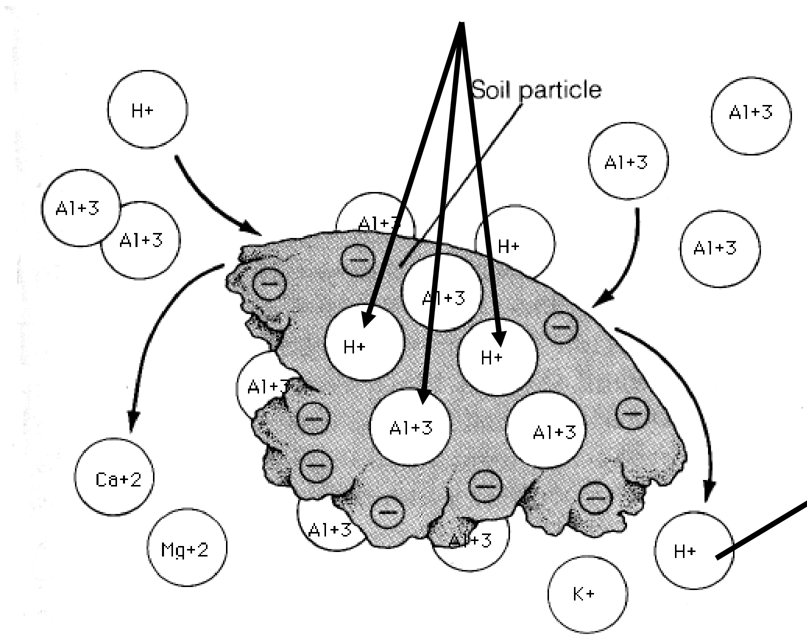


N Fixation
Common N Fertilizers
Agricultural N Cycling
Potential N Loss
Ammonium Nitrate
(NH4NO3)
DISSOLUTION
Nitric
Acid
Heat +
Pressure
DENITRIFICATION
Heat +
Pressure
CO2
HYDROLYSIS
NITRIFICATION
Atmospheric N
+
Hydrogen
Ammonia
(NH3)
Urea
(NH2CONH2)
Ammonia
(NH3)
Ammonium
(NH4+)
Nitrite
(NO2-)
Nitrate
(NO3-)
(or)
Biological N
Fixation
LEACHING
Biological
Activity
MINERALIZATION
Organic N
(humus)
Prunings/Leaf Litter
Vine Root
Uptake
GRAPE
HARVEST

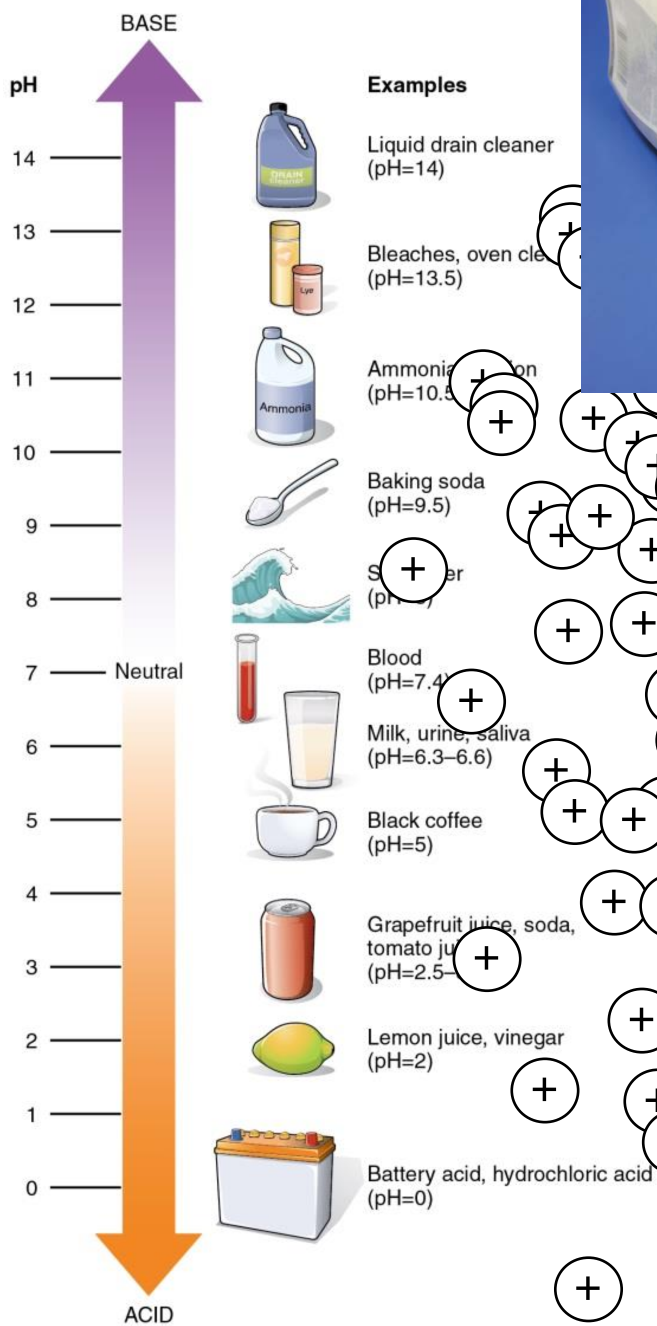
Agricultural Lime

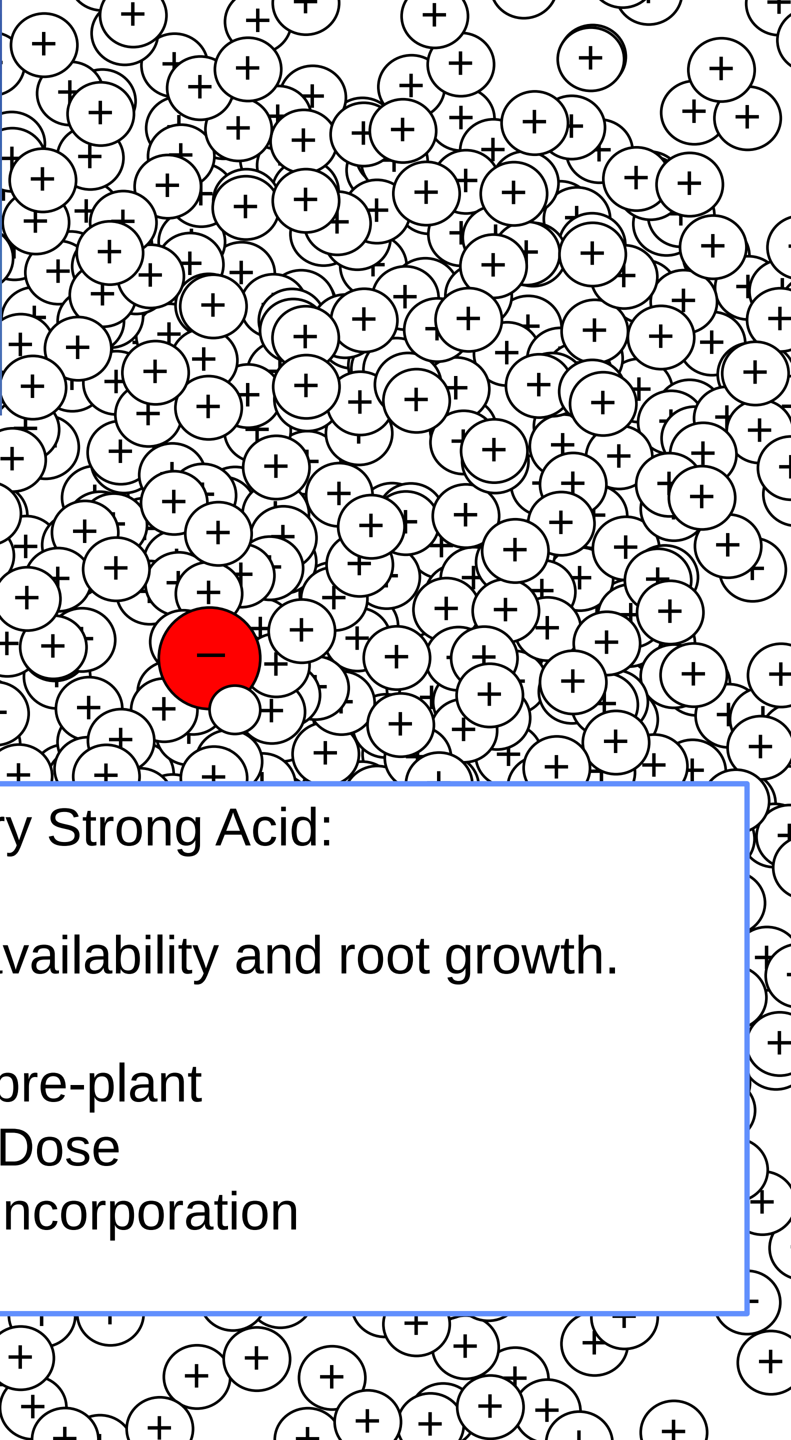
$CaCO_3$

Ca^{++} CO_3^{--}



HCO_3^{-}





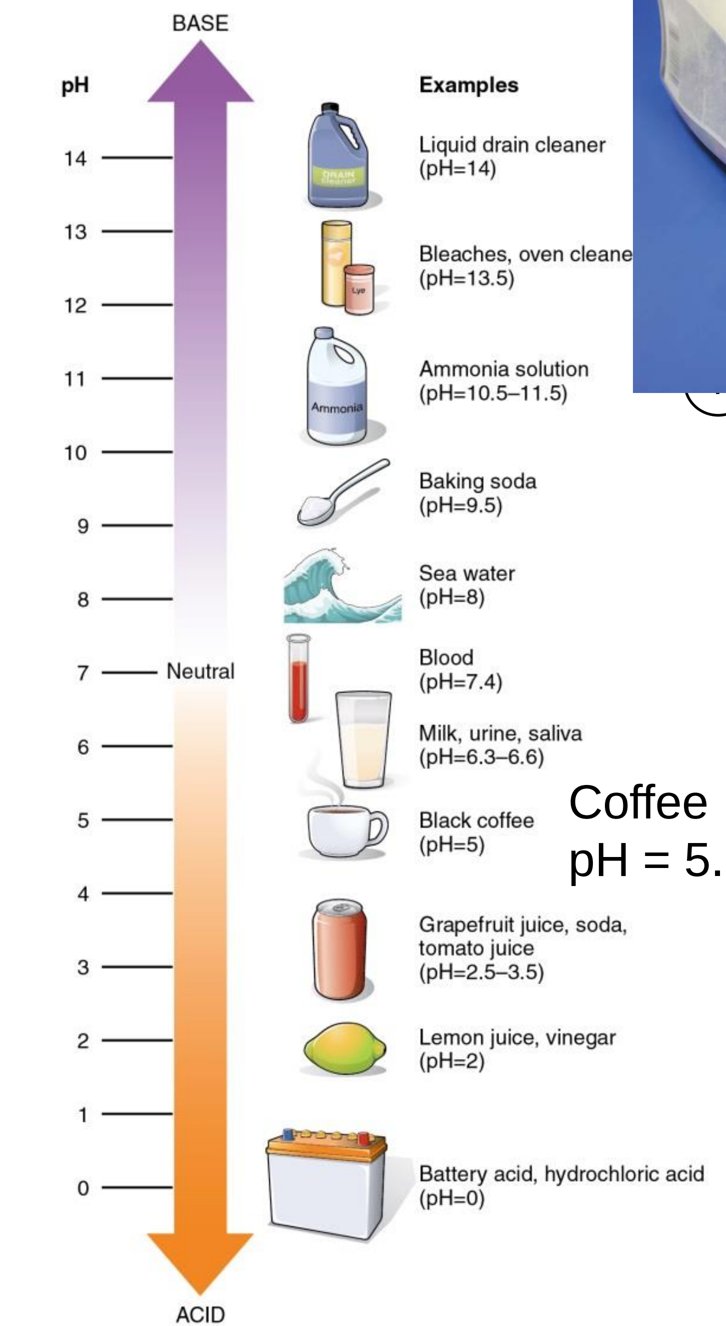
Extreme to Very Strong Acid:

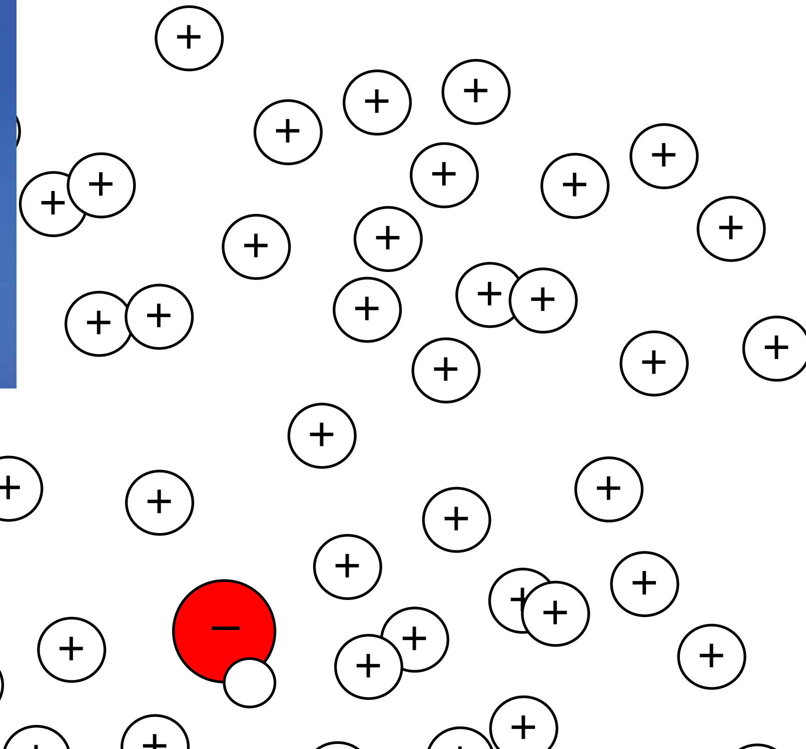
Poor nutrient availability and root growth.

Best adjusted pre-plant

Large Dose

Deep Incorporation





Coffee
pH = 5.0

Moderate to Strong Acid:

Established Vineyards

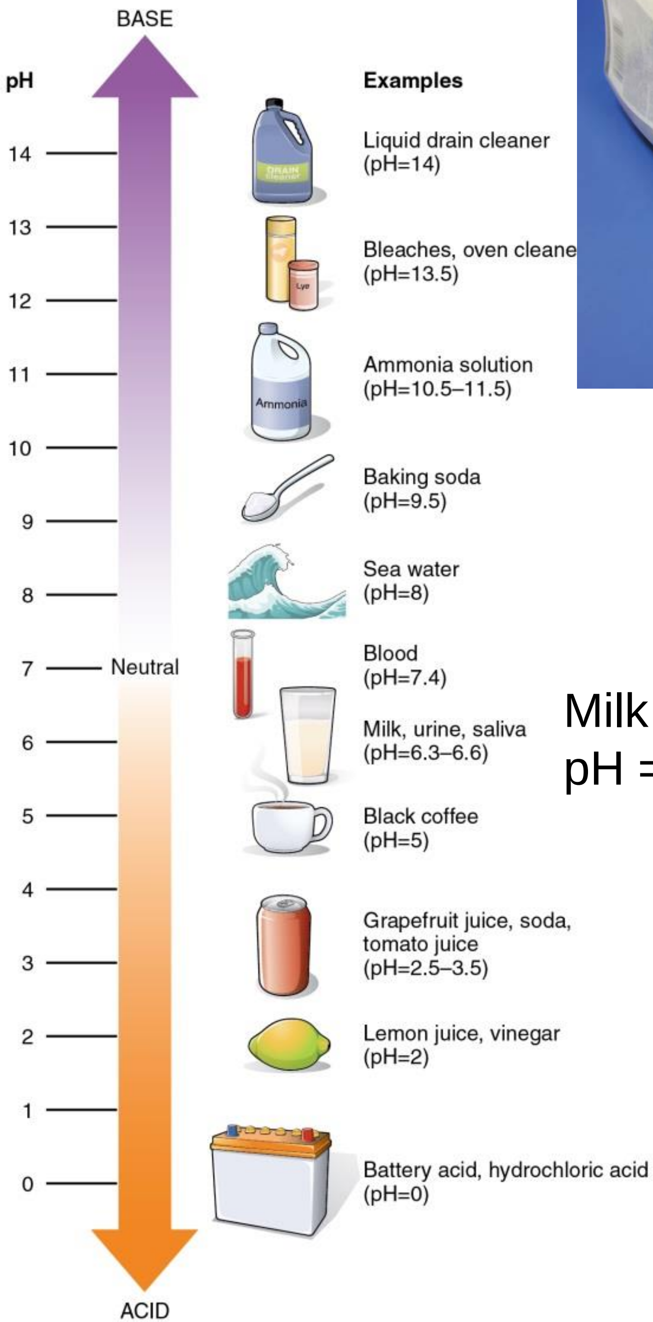
Moderate Lime Rates

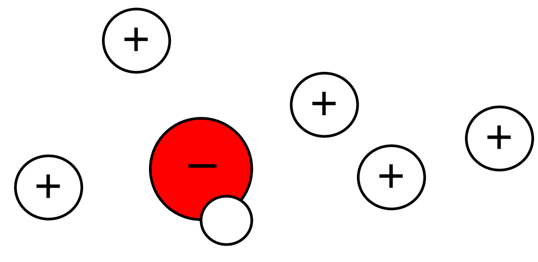
<2 tons lime / acre / year

Incorporation?

Pelletized Lime?

http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg





Milk
pH = 6.0

Slight Acid:

Good Nutrient Availability
Good Root Function

Maintenance Lime Based on Other Fertilizer (N) Applications

http://upload.wikimedia.org/wikipedia/commons/2/23/216_pH_Scale-01.jpg

Vineyard Soil pH and Mineral Nutrition

1) Mineral Nutrient Availability: Soil pH

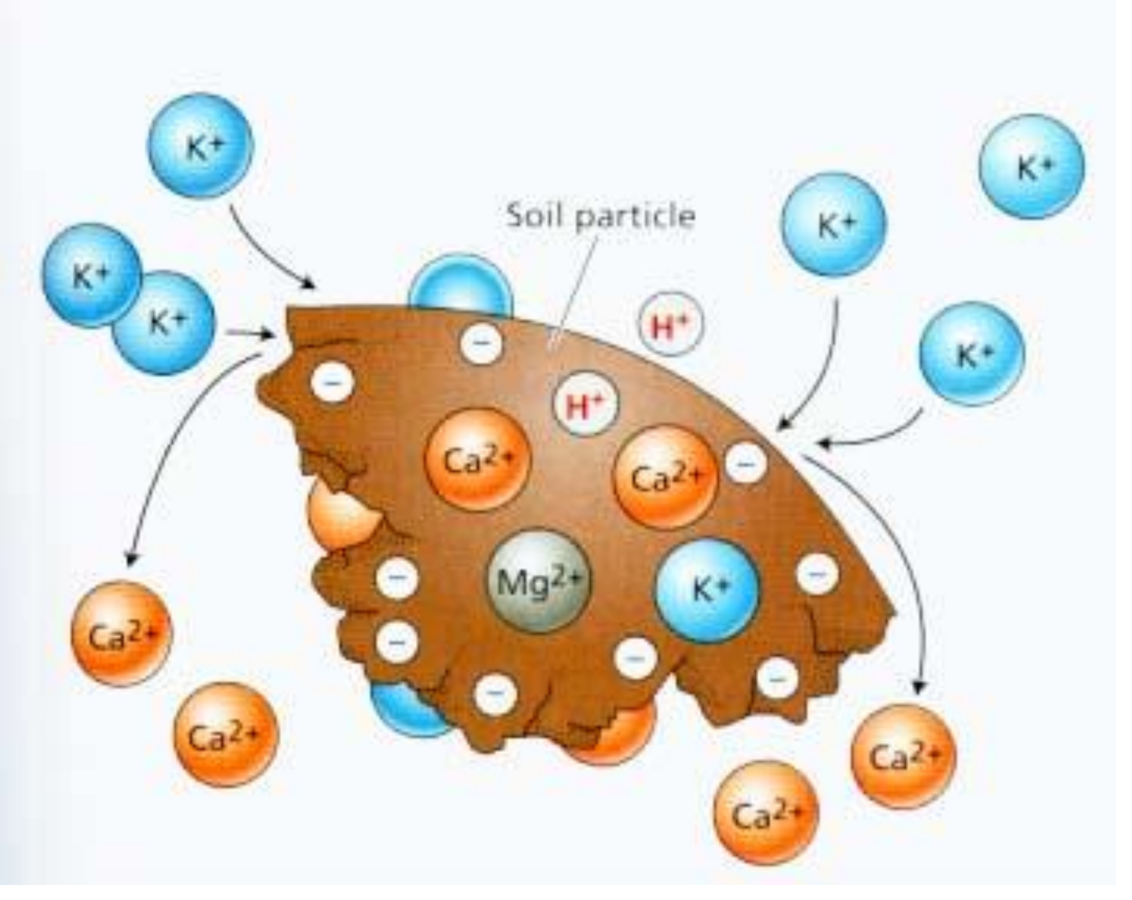
2) Mineral Nutrient Balance: CEC

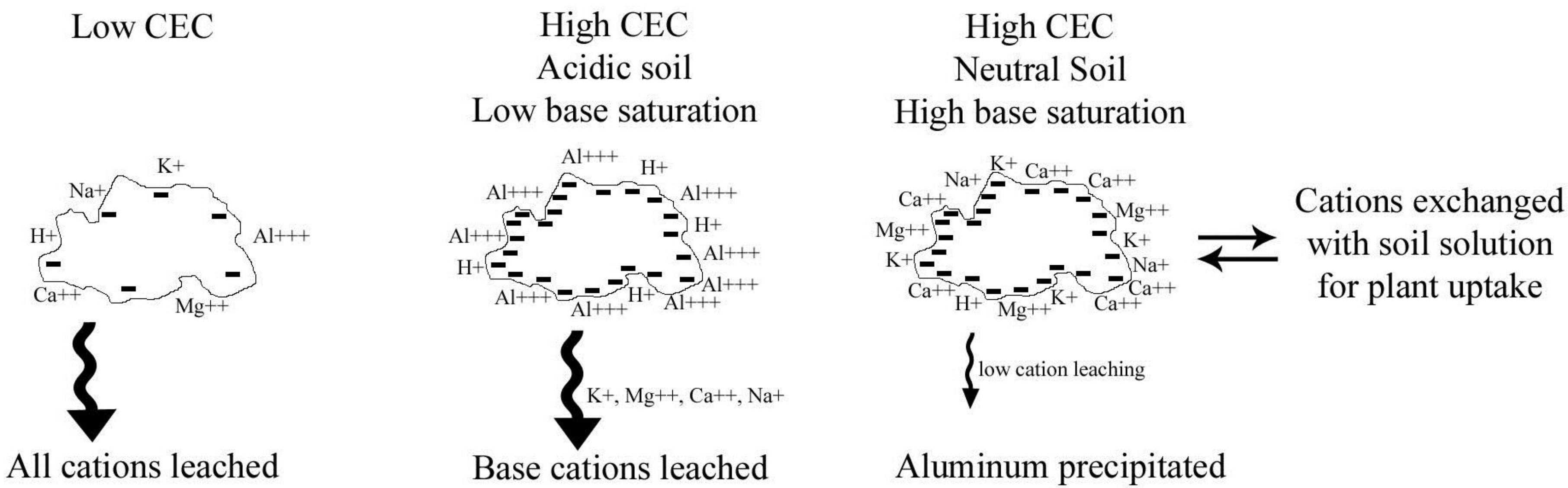
3) Mineral Nutrient Demand: Management Considerations

Cation Exchange Capacity

Strength of Cation Adsorption

Al > Ca > Mg > K = NH > Na

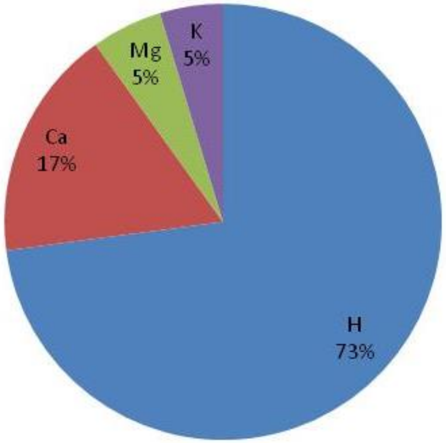


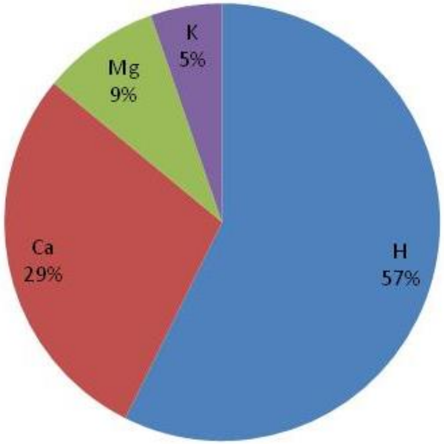


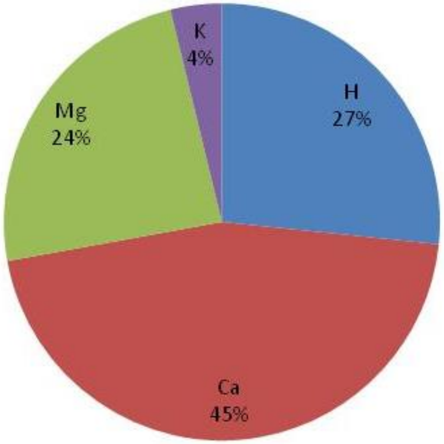
Low CEC
K+
Na+
H+
Al+++
Ca++
Mg++
All cations leached
High CEC
Acidic soil
Low base saturation
Al+++
H+
Al+++
Al+++
H+
Al+++
H+
Al+++
Al+++
Al+++
Al+++
H+
Al+++
K+, Mg++, Ca++, Na+
Base cations leached
High CEC
Neutral Soil
High base saturation
K+
Na+
Ca++
Ca++
Ca++
Mg++
Mg++
K+
K+
Na+
Ca++
Ca++
H+
Mg++
K+
Ca++
low cation leaching
Aluminum precipitated
Cations exchanged
with soil solution
for plant uptake

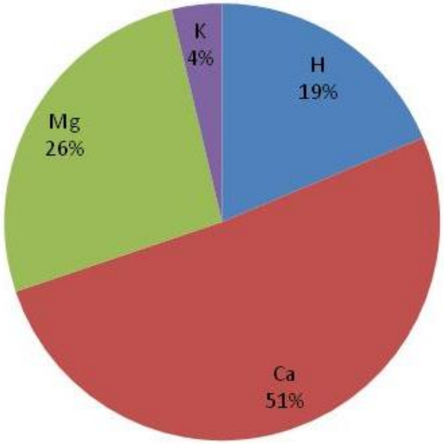
Soil pH

Very Strong Acid 4.5-5.0	Strong Acid 5.1-5.5	Moderate Acid 5.6-6.0	Slight Acid 6.1-6.5

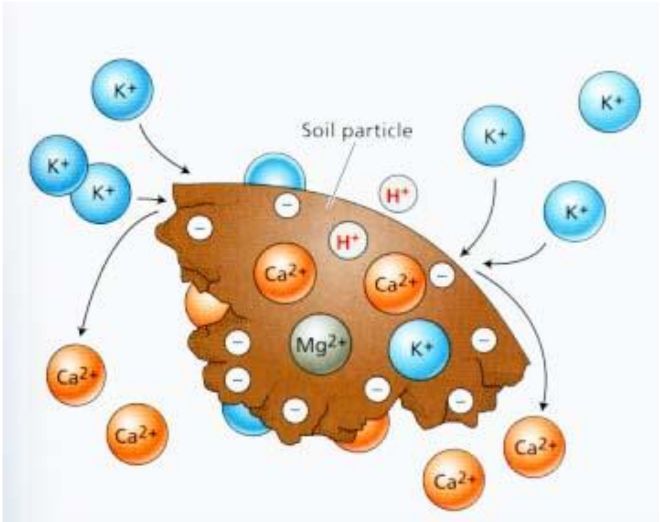








- Hydrogen
- Calcium
- Magnesium
- Potassium

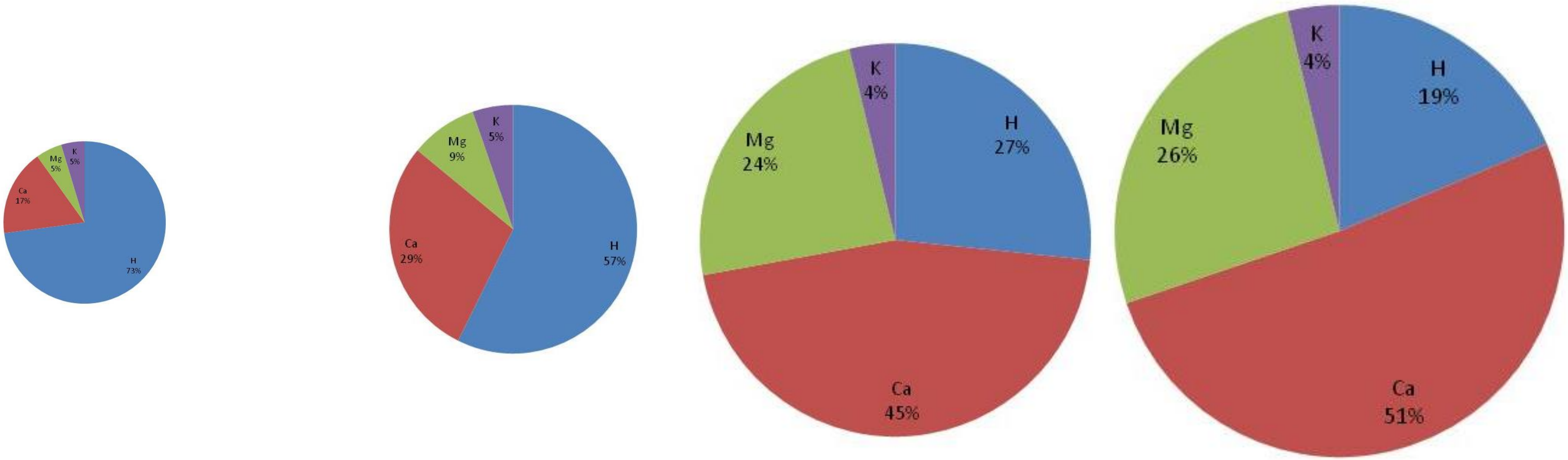


Soil pH

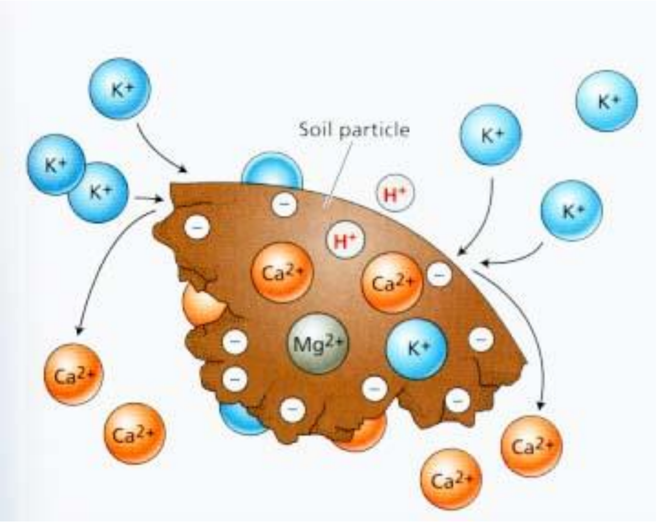
Very Strong Acid	Strong Acid	Moderate Acid	Slight Acid
4.5-5.0	5.1-5.5	5.6-6.0	6.1-6.5

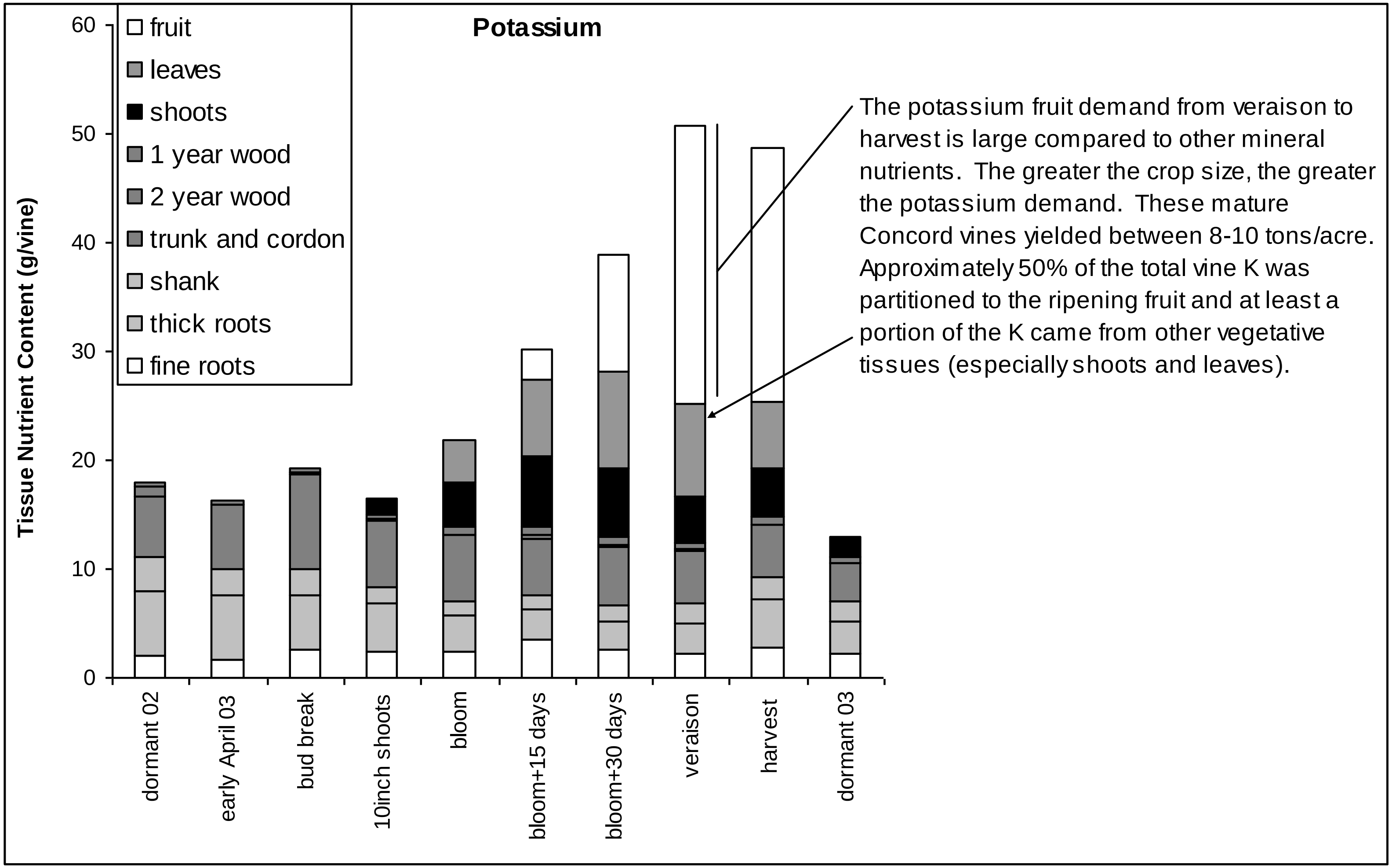
CEC

3.5	5.3	8.7	9.5



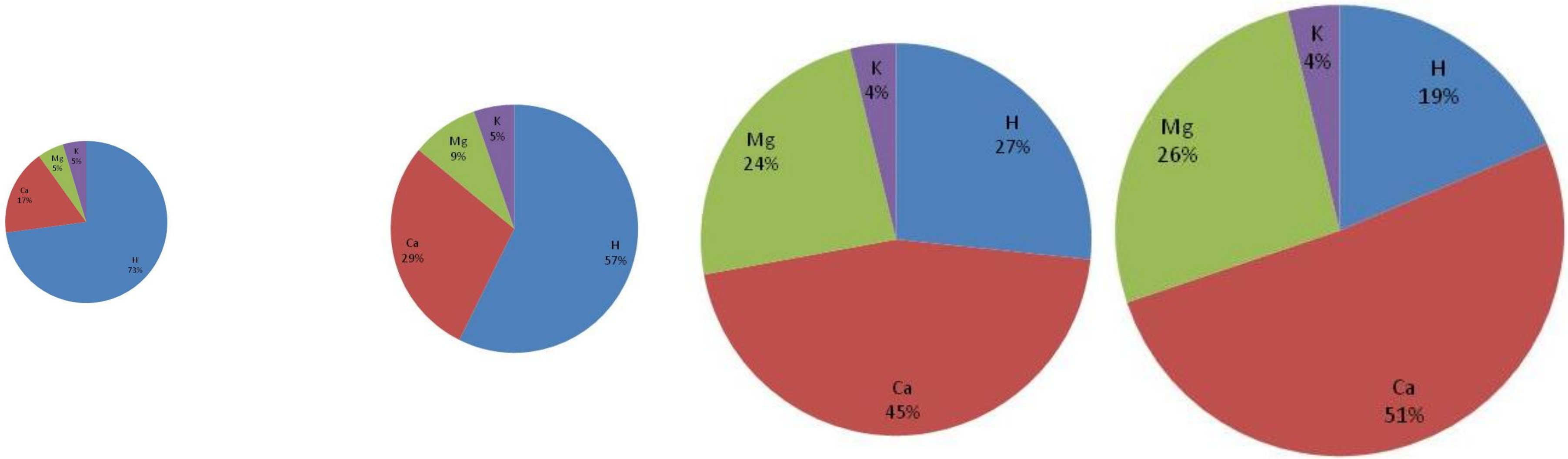
- Hydrogen
- Calcium
- Magnesium
- Potassium

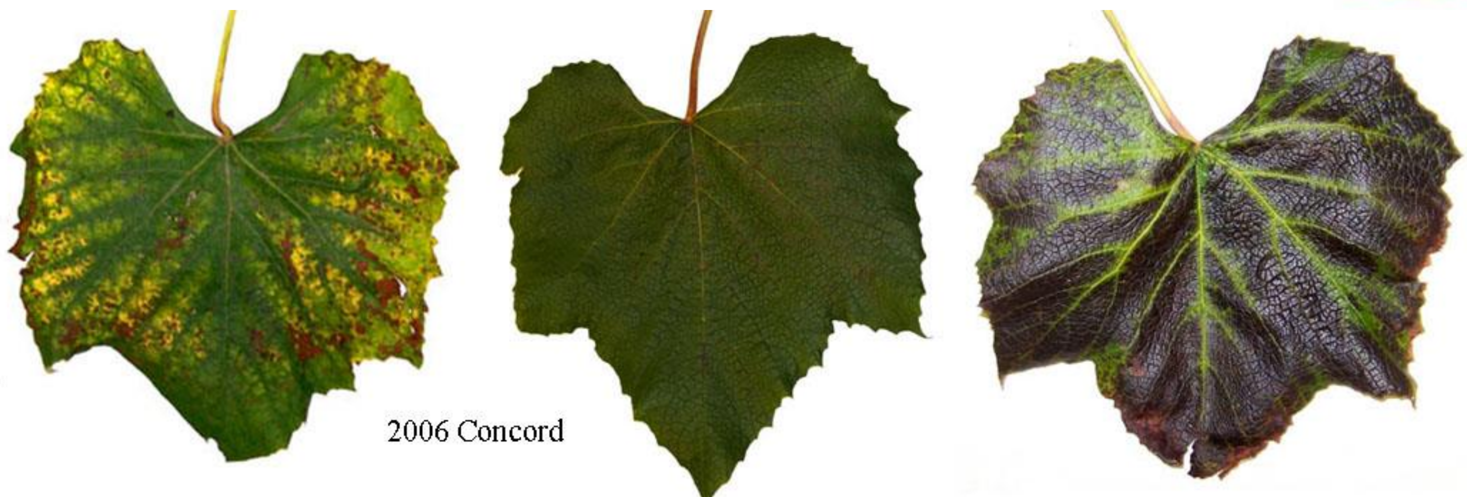




Vine tissue amount and annual demand

Soil pH	Very Strong Acid 4.5-5.0	Strong Acid 5.1-5.5	Moderate Acid 5.6-6.0	Slight Acid 6.1-6.5
CEC	3.5	5.3	8.7	9.5





Acid soil (Mg) Deficiency   Healthy Nutrient Balance   Potassium Deficiency

Soil Acidity and Concord Vine Size: 2001-2006

			Grown Pruning Weight (pounds/vine)											
	soil pH	fertilizer	2001		2002		2003		2004		2005		2006	
Very Strong Acid	1	no	2.1		1.5	c	1.9	b	3.1	b	2.2	c	2.4	bc
	1	yes	2.1		1.7	bc	2.0	b	3.4	ab	2.3	bc	2.4	bc
Strong Acid	2	no	2.3		2.0	ab	2.3	ab	3.7	ab	2.6	ab	2.7	ab
	2	yes	2.5		2.2	a	2.6	a	4.0	a	2.8	a	3.7	a
Moderate Acid	3	no	2.3		2.0	ab	2.1	ab	3.2	b	2.2	c	1.5	cd
	3	yes	2.1		2.1	ab	2.1	b	3.3	b	2.4	bc	2.8	ab
Slight Acid	4	no	2.3		1.9	ab	1.9	b	3.3	b	2.2	c	1.2	d
	4	yes	2.2		1.9	ab	1.8	b	3.2	b	2.3	bc	2.4	bc
	soil pH		*NS*		*		*		*		**		**	
	fertilizer		*NS*		*NS*		*NS*		*NS*		*		**	
	*soil pH*fertilizer*		*NS*		*NS*		*NS*		*NS*		*NS*		*NS*	

Vineyard Soil pH and Mineral Nutrition

1) Mineral Nutrient Availability: Soil pH

2) Mineral Nutrient Balance: CEC

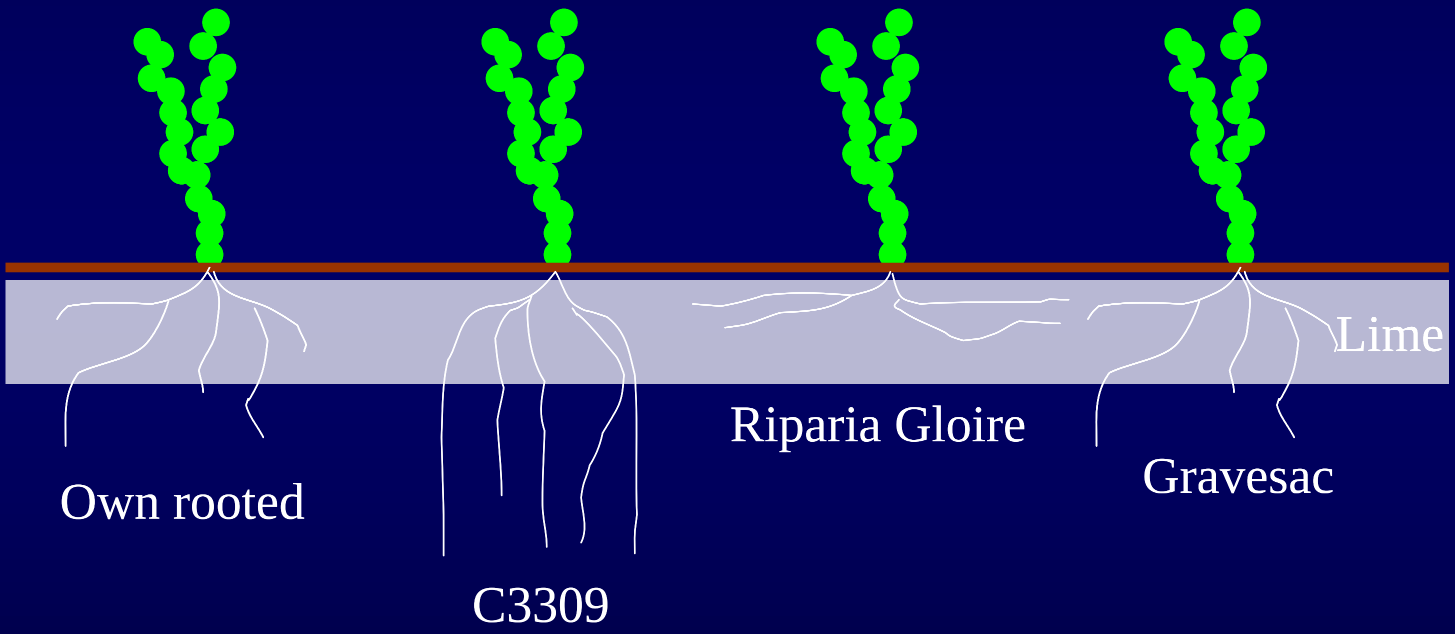
3) Mineral Nutrient Demand: Management Considerations

Not all roots grow the same

4 Varieties X 4 Root Systems X 2 Soil pH

4 Scion Varieties

White Riesling (clone 239) | Cabernet Sauvignon (clone 8)
Traminette | Noiret



The treatment combinations

Soil pH: Different looks at the same problem

Soil pH, Rootstock, and Variety

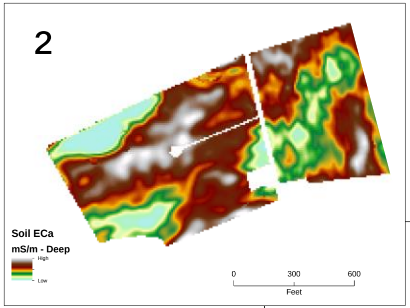
Canopy assessment:

		Vine Size dormant cane pruning weight (kg/m)							
Rootstock	**Soil**	**Riesling**		**Traminette**		**Cab Sauv**		**Noiret**	
own rooted	no lime	0.05	c	0.25	f	0.11	e	0.32	b
	lime	0.09	c	0.41	ef	0.19	e	0.44	b
Riparia Gloire	no lime	0.27	b	0.50	de	0.54	d	0.56	b
	lime	0.41	ab	0.54	cde	0.62	cd	0.83	a
Gravesac	no lime	0.34	b	0.67	bcd	0.86	ab	0.84	a
	lime	0.52	a	0.71	ab	1.02	a	1.09	a
3309C	no lime	0.39	ab	0.69	bc	0.77	bc	0.87	a
	lime	0.52	a	0.88	a	0.94	ab	1.07	a
Sig (p)									
Rootstock		**		**		**		**	
Soil		*		*		*		*	
Rootstock x Soil		ns		ns		ns		ns	

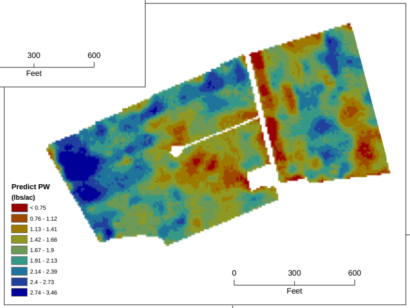
The effect of treatments on vine size

Integrated Deployment

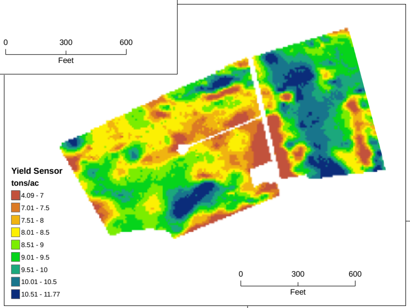
5 Test Vineyards



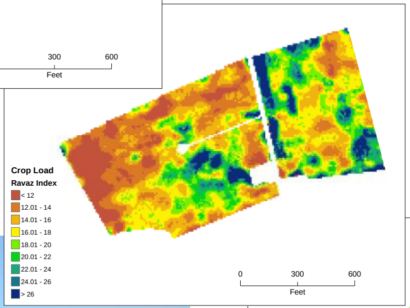
Soil



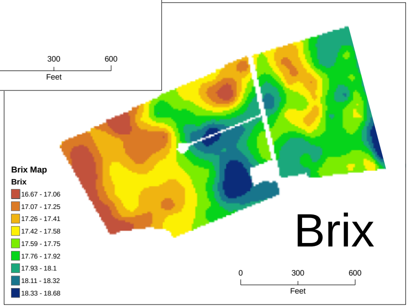
Canopy



Crop



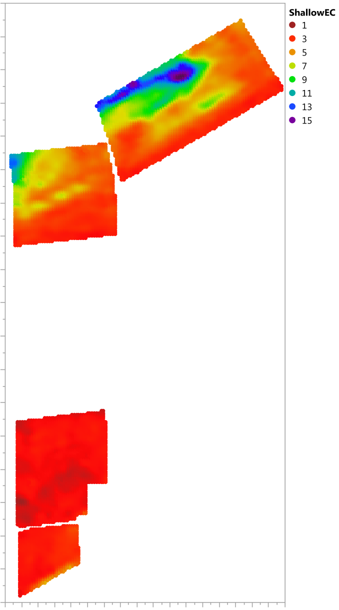
Crop Load



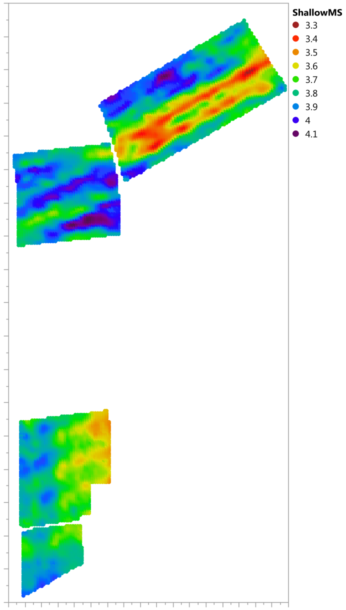
Brix

Concord

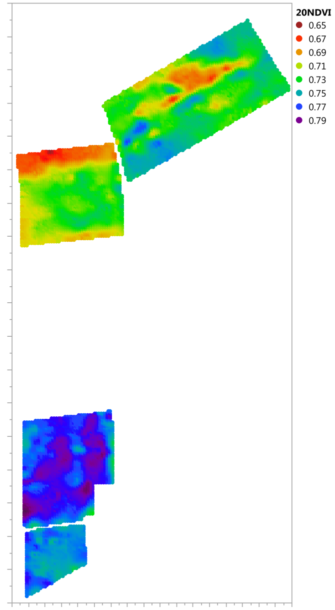
Soil EC



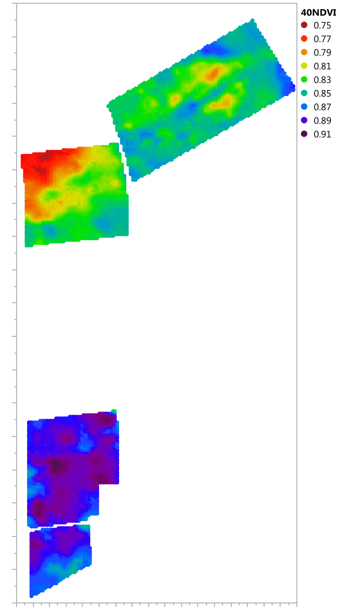
Soil MS



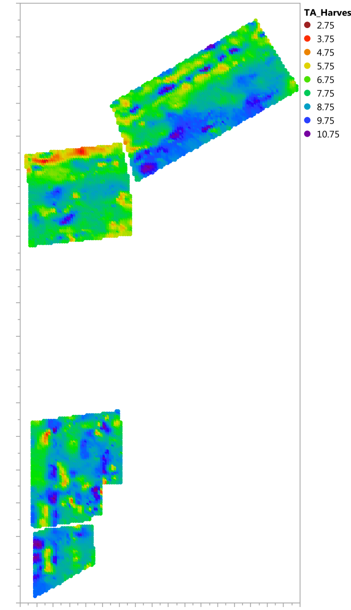
NDVI (20 DAB)



NDVI (40 DAB)



Yield (GYM)



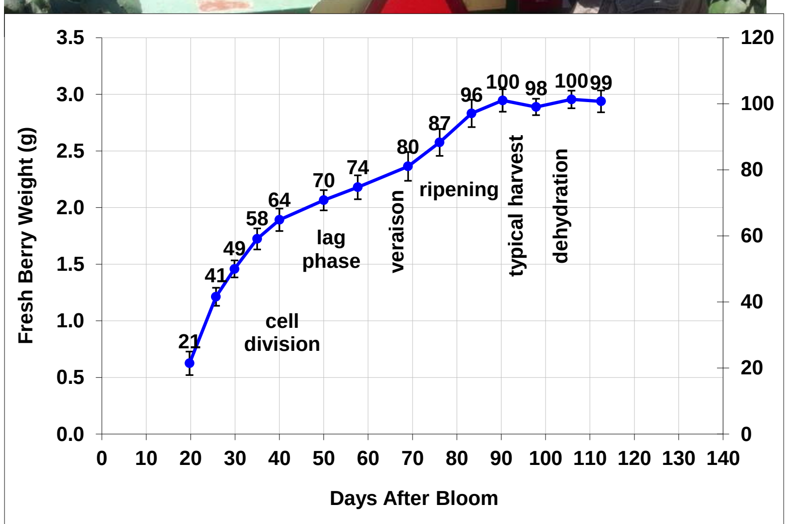
<u>Correlations</u>

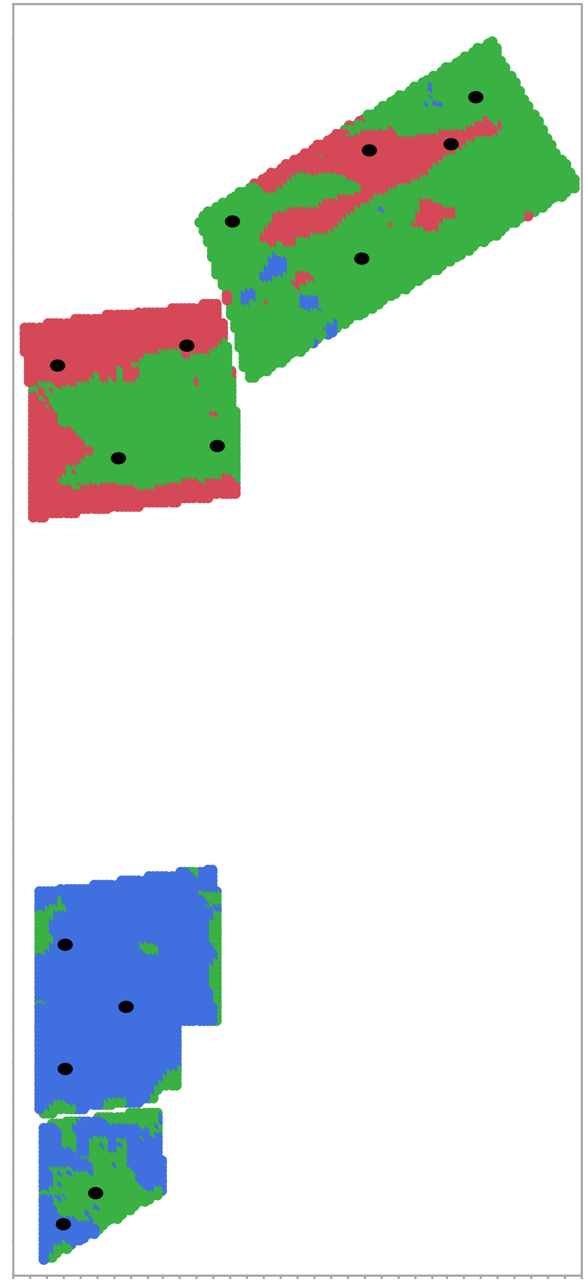
Soil Electrical Conductivity (Shallow EC) to NDVI (@20 DAB): [-0.6339]

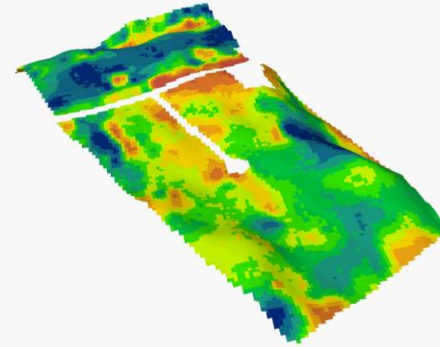
NDVI (@20 DAB) to Yield (Grape Yield Monitor): [0.4464]

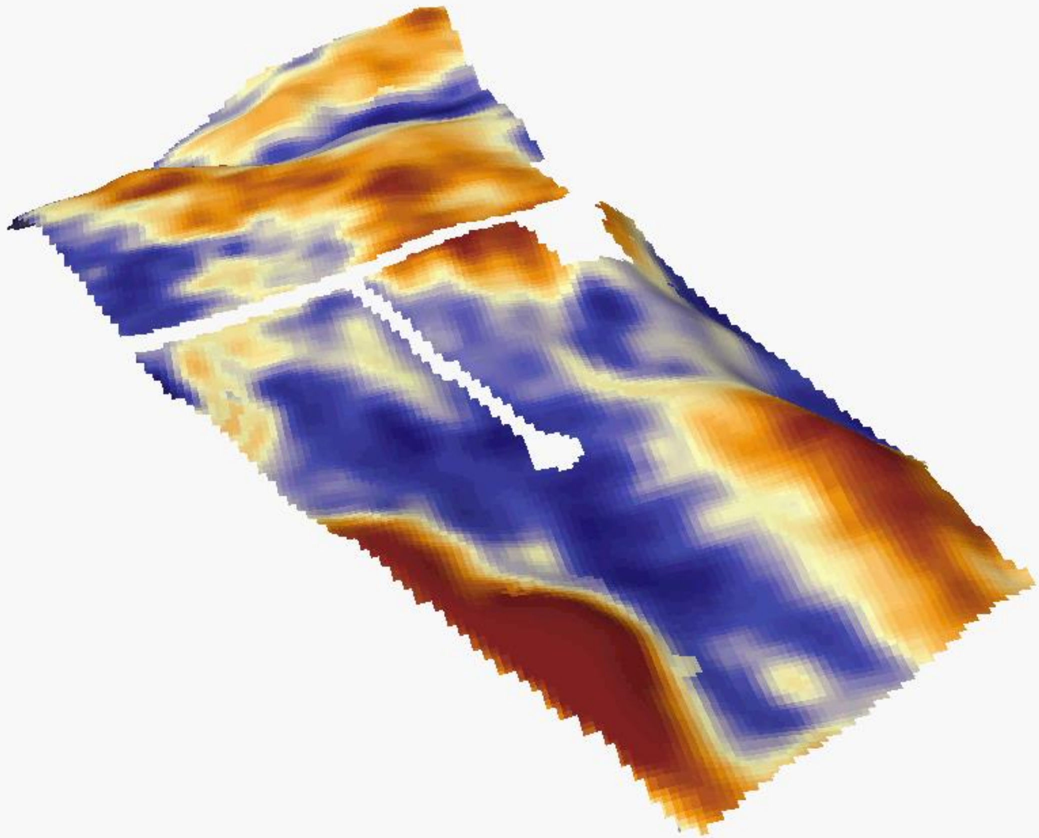
One potential Management Map based on Soil EC, MS, and Early season NDVI.

Crop Estimation by Stratified Sampling









Take Home Messages

Soil Acidity varies within and between vineyards
(and tends to decrease over time due to plant nutrient uptake and N fertilization).

Soil Acidity changes the effective CEC and ion saturation balance.

At low to moderate crop stress, there was little effect of soil pH (4.5-6.5) on vine productivity…(but be careful).

At high crop levels, the Potassium supply and demand relationship becomes important.