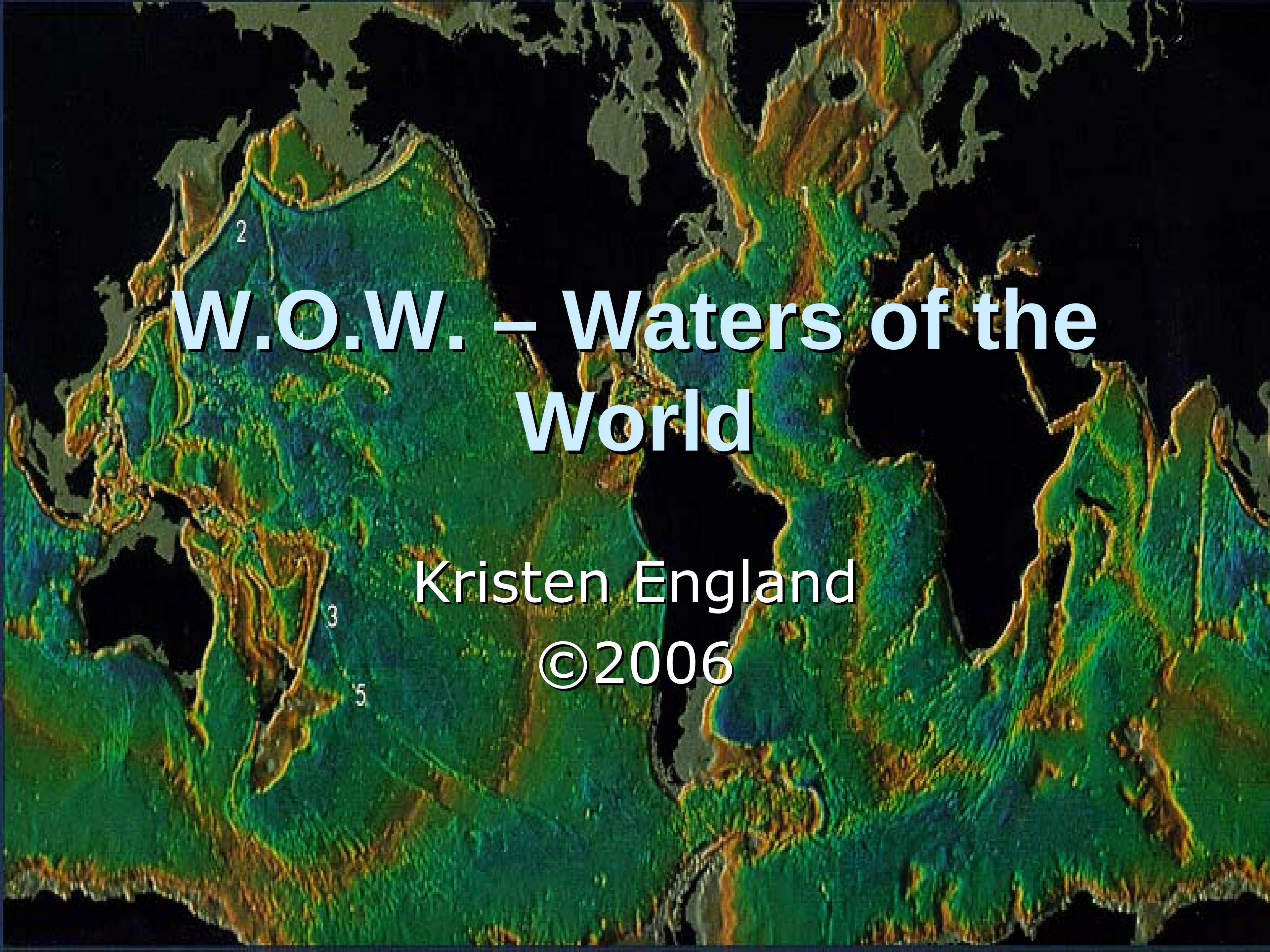

W.O.W. – Waters of the World

Kristen England

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First things smirst

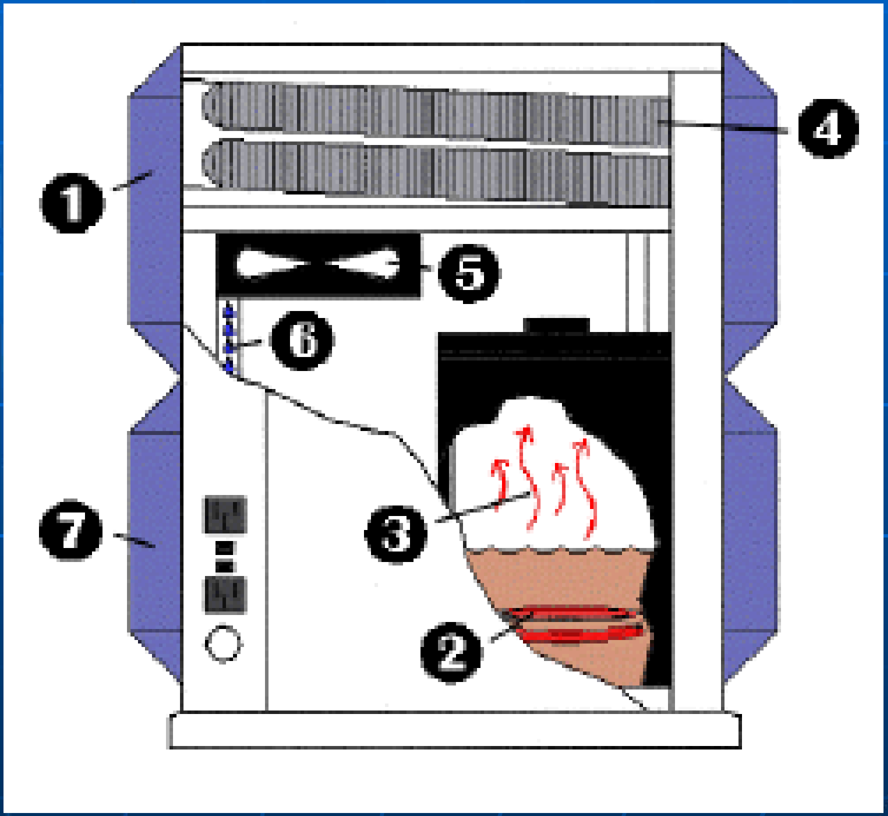
- ~95% beer is aqua
- Styles developed b/c of the water of the city

Types-O-Aqua

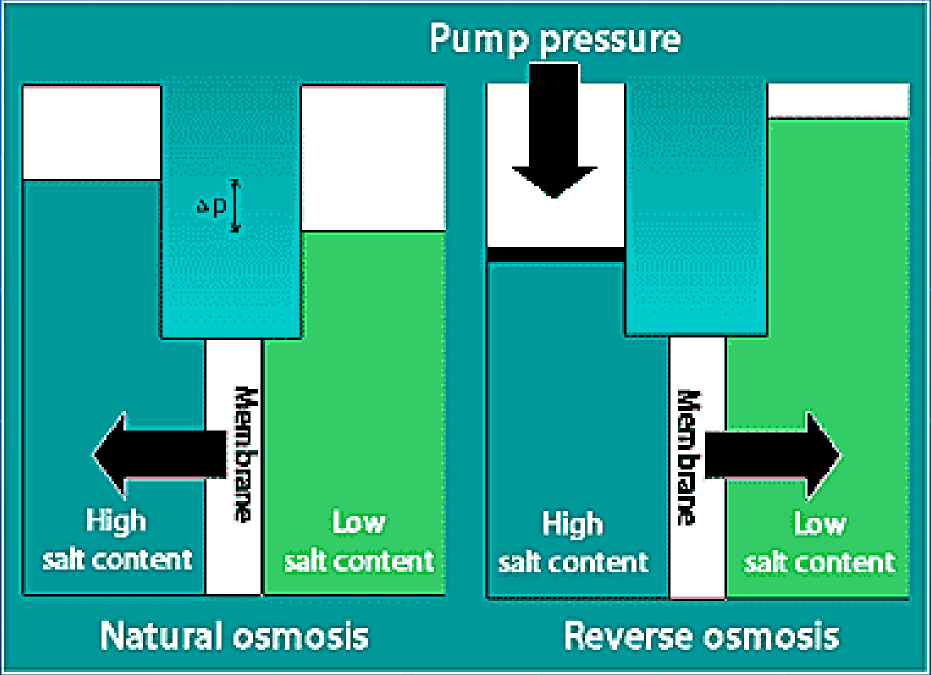
- Tap water
- Spring water
- RO water
- Distilled water
- ‘Heavy’ water
  - Deuterium isotope – good for things like the Manhattan project NOT brewing

Distilled Water

1. Contaminated water
2. Heat from the heating element
3. Evaporation of H_2O molecules
4. Condenser
5. Cool air from fan
6. Distilled water
7. Distilled water storage

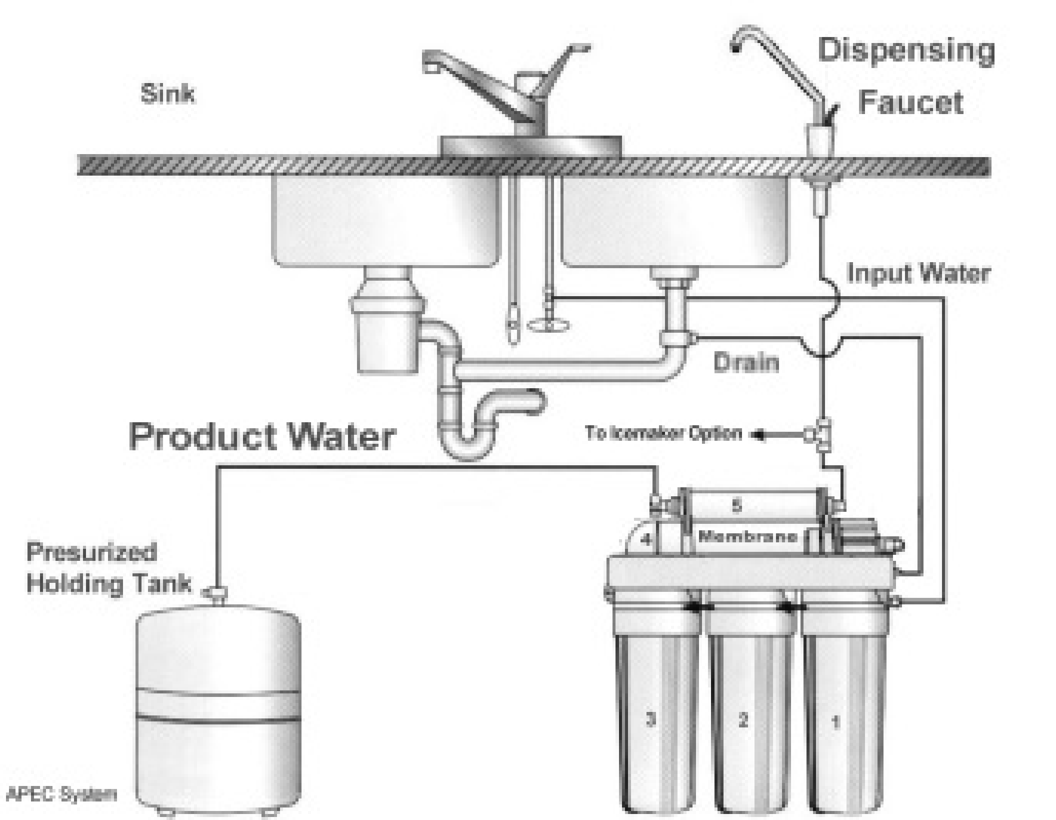


RO Water



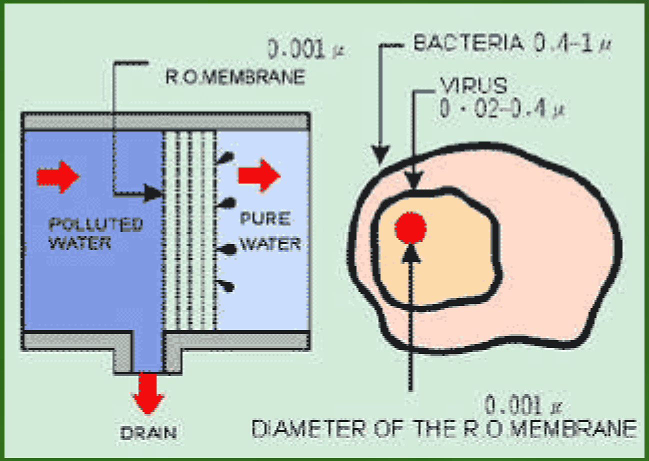
- A method of producing pure water by forcing saline or impure water through a semipermeable membrane across which salts or impurities cannot pass.

RO – Under counter



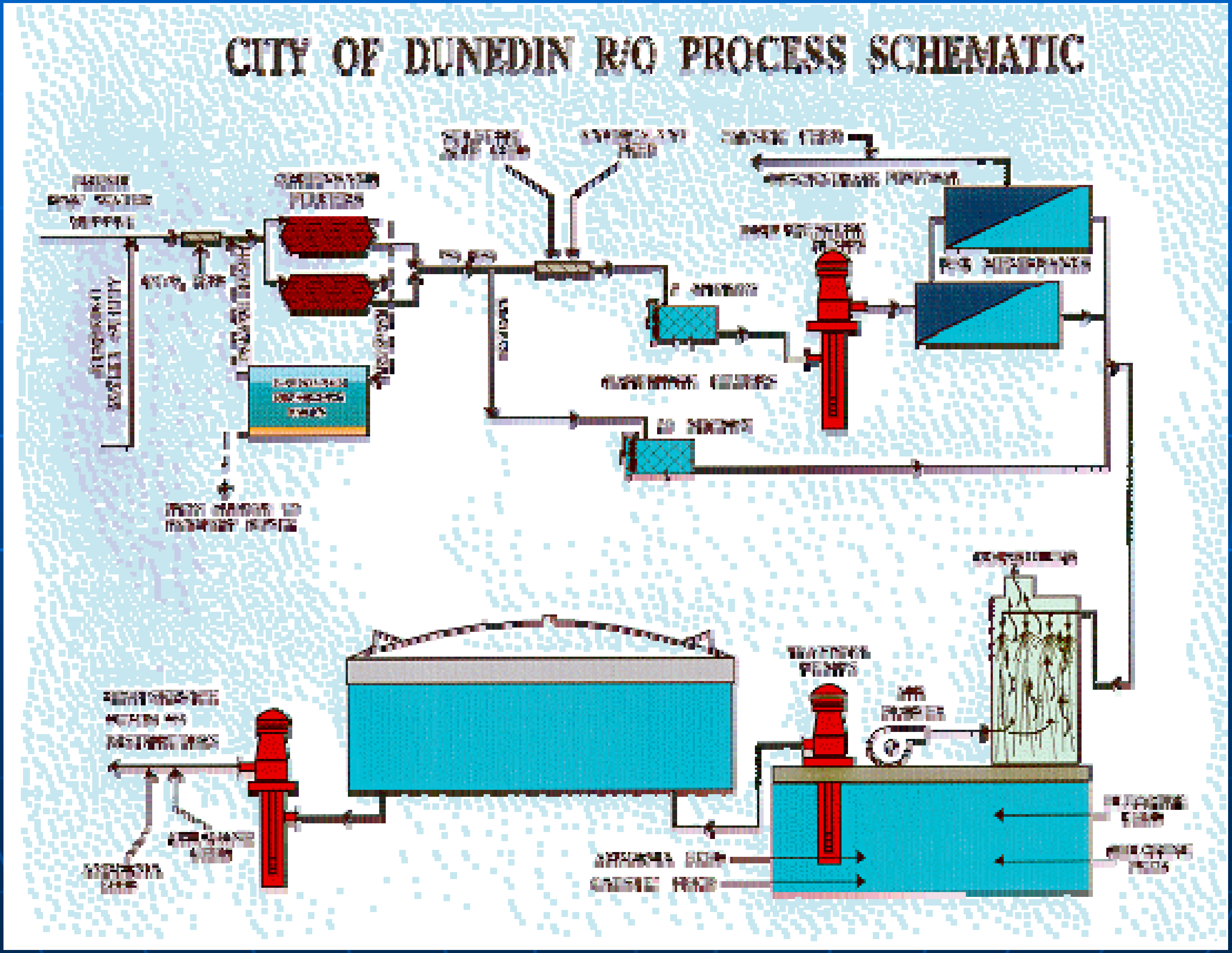
- ***Stage 1 - Sediment Prefiltration*** - 1 micron cartridge that traps dirt, rust, mud, hair
- ***Stage 2 - Chlorine Prefiltration -*** 1 micron chemical removal cartridge to ensure no chemical deterioration of membrane from residual chlorine.
- ***Stage 3 - Membrane Process***
  This is the primary component that can separate up to 98% of dissolved metals and minerals from ordinary tap water.

RO - Membrane pore size



Yeast 5-12u

RO – City Scale



Spring Water

- Spring water is water that comes out of the ground on its own or is bottled near water that comes out of the ground on its own.
- Check ion content

Tap Water – The Bad

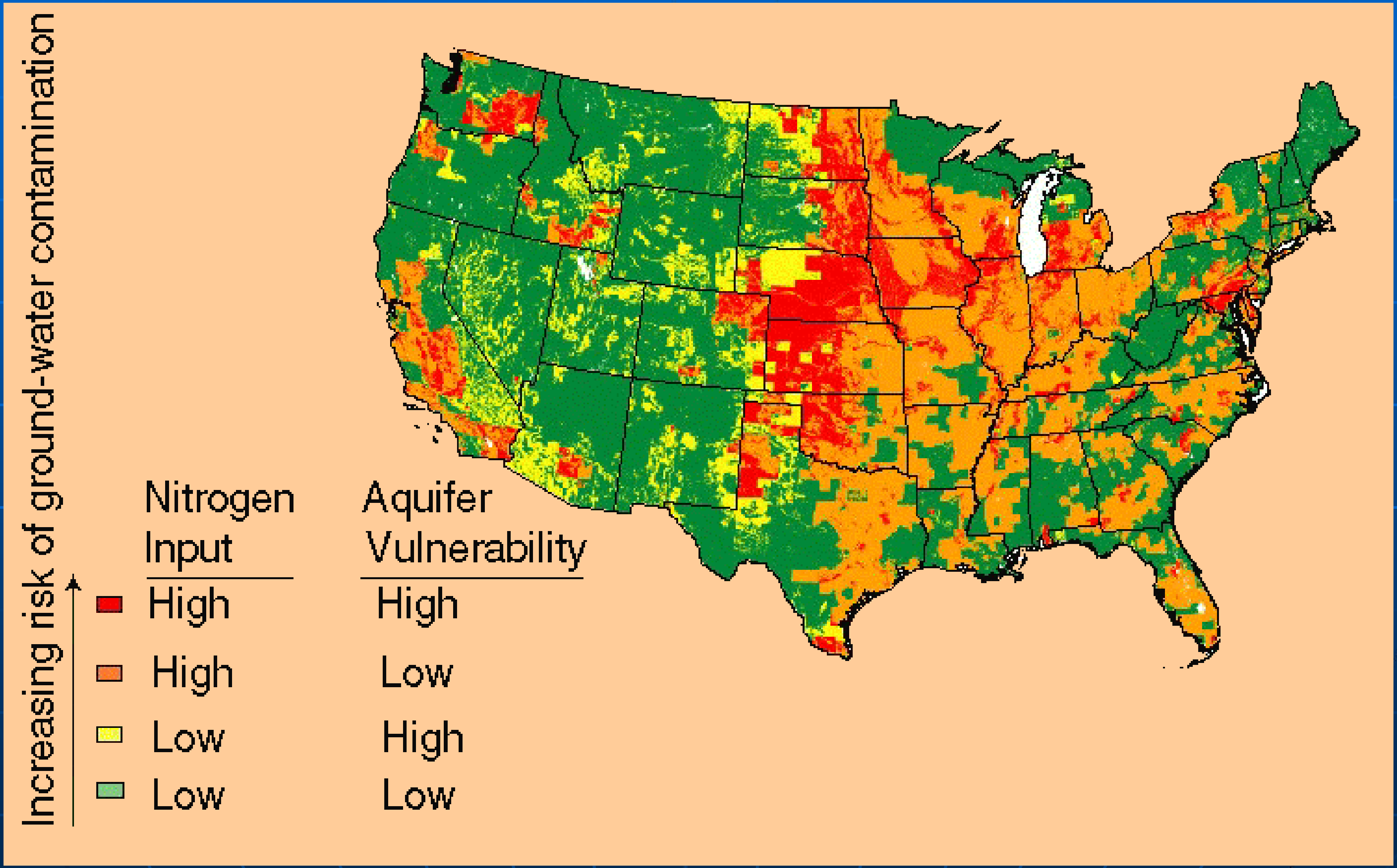
- ‘Bad’
  - Non-potable
  - Chlorine and/or Chloramines
  - Sulfur
  - Nitrates – ummm…poop
  - Corn chips, old feet, etc

Chlorine, borine!!!

- Chlorine gas
  - Used VERY little
  - Boils off easily

- Chloramines
  - Used most often
  - Need carbon filter to remove
    - Sulfate and UV bs
  - Boil only concentrates!!

Nitrates = POO!



Tap Water – The Good

- Good
  - Anything you can drink - potable water
  - Well water
  - NOT through ‘softener’
  - Carbon filtered
    - Removes Cl and other nasty stuff

Activated Carbon

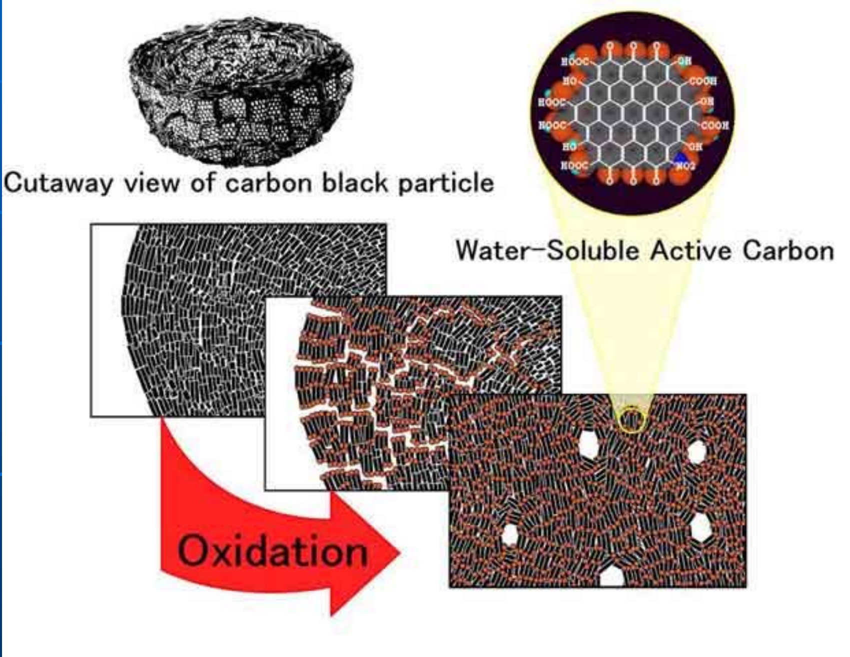


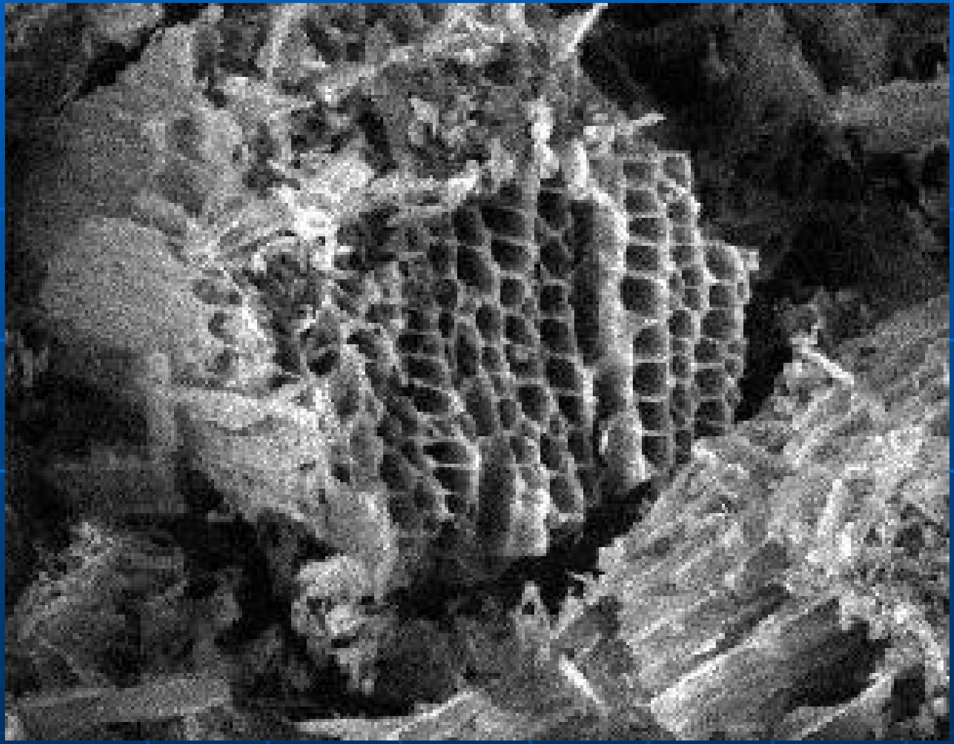
Figure 1. Schematic representation of formation of Water-Soluble Active Carbon from carbon black.

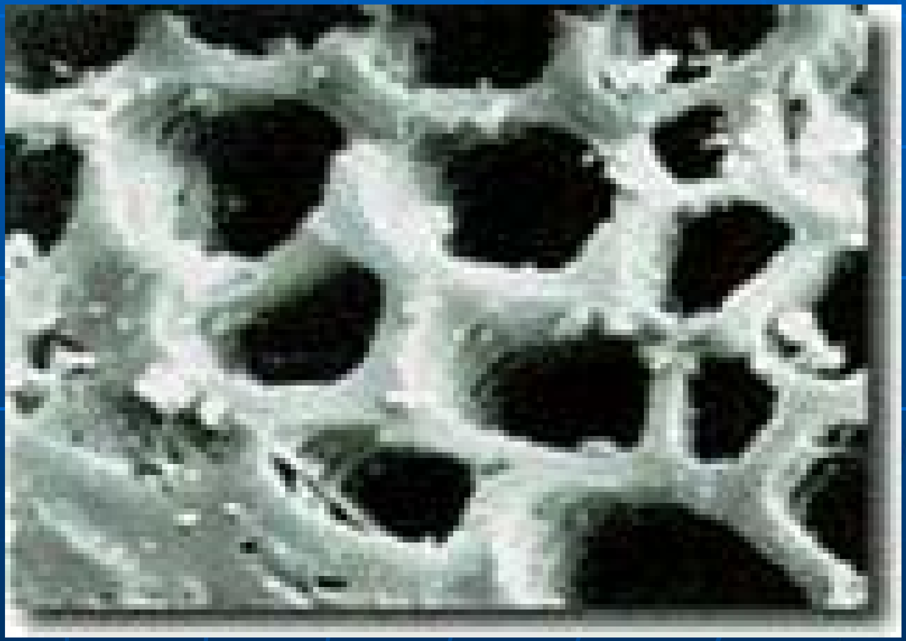
- Uses
  - Air purification
  - Water purification
  - Booze purification
  - Hospital

Activated Carbon

- Charcoal that has been treated with **oxygen**
- 300-2,000 m^2/g (3200-21500 ft^2/g)
  - A tennis court is about 260 m^2 (2800ft^2/g)
- Trap
  - Carbon-based contaminants – flavor and odorous stuff
  - Chlorine
- Pass
  - Sodium, Nitrates
- Good at trapping other carbon-based impurities ("organic" chemicals), as well as things like chlorine.
- Once all of the bonding sites are filled, an activated charcoal filter stops working.

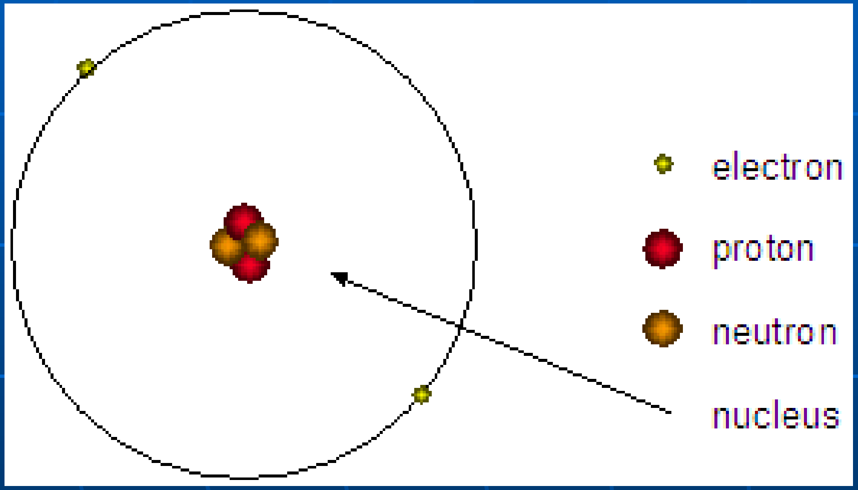
Ummmm….honeycomb!





Chemistry Primer

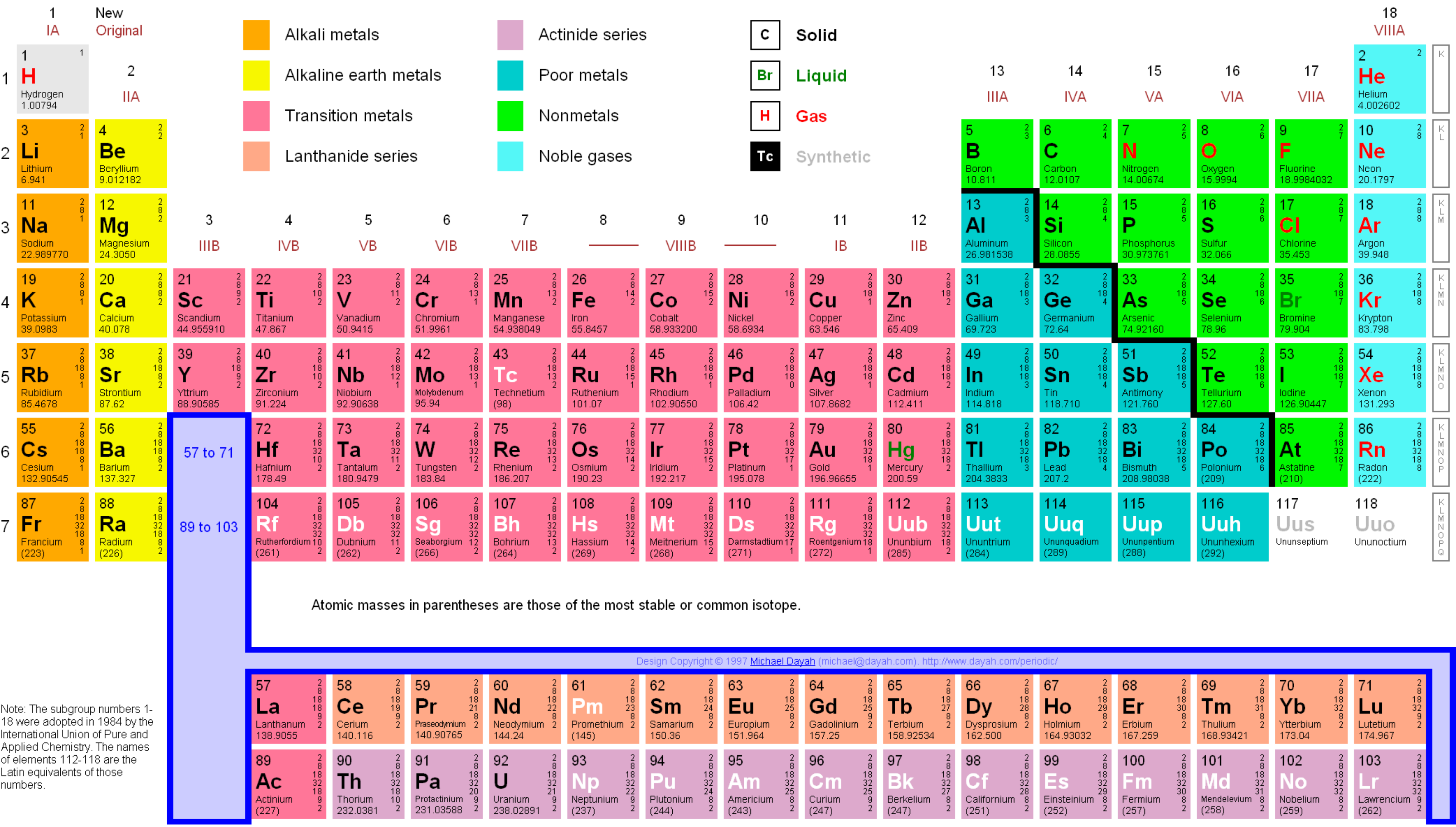
Atoms



- Atoms are composed protons, neutrons, and electrons.
- ***Protons*** and ***neutrons*** are located in a central area called the nucleus.
- ***Electrons*** move about the nucleus. The number of electrons is equal to the number of protons.
  - Electrons in cloud, not ring

Periodic Table of the Elements

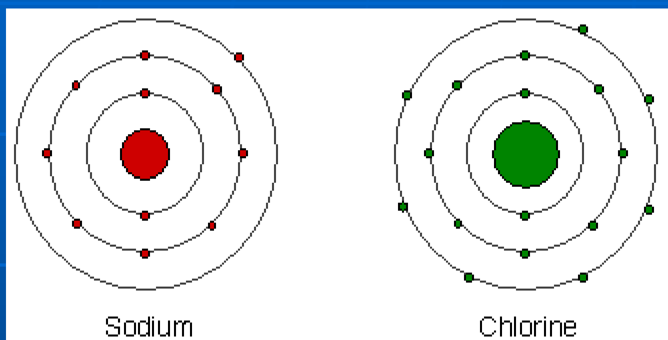
Elementary my dear Watson!!

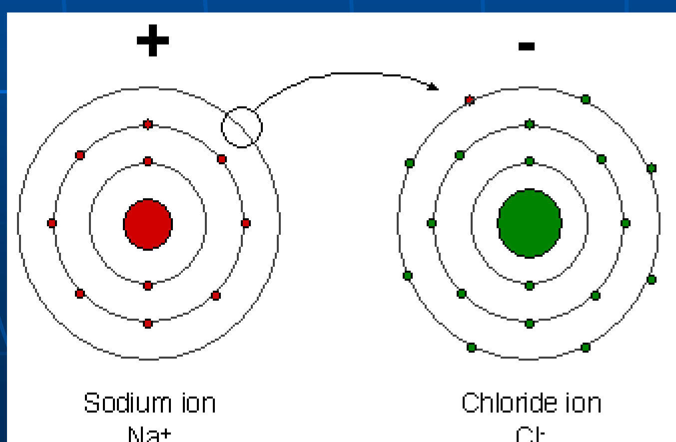


Compounds

- Elements cannot be broken down into substances with different properties.
- Substances that are composed of two or more elements are called ***compounds***.
- For example, water (H2O) is not an element because it can be broken down into hydrogen (H) and oxygen (O).

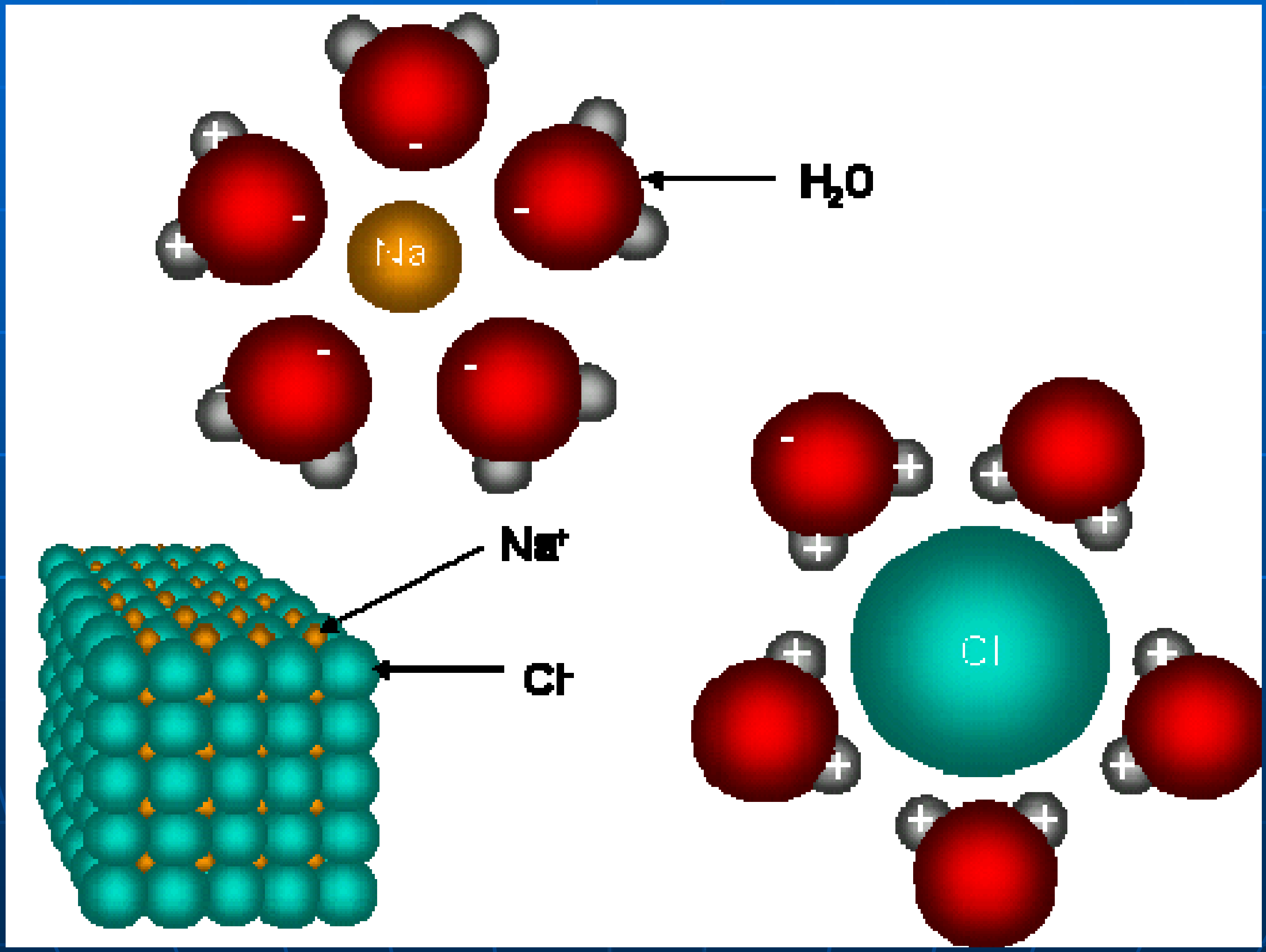
Ionic Compound



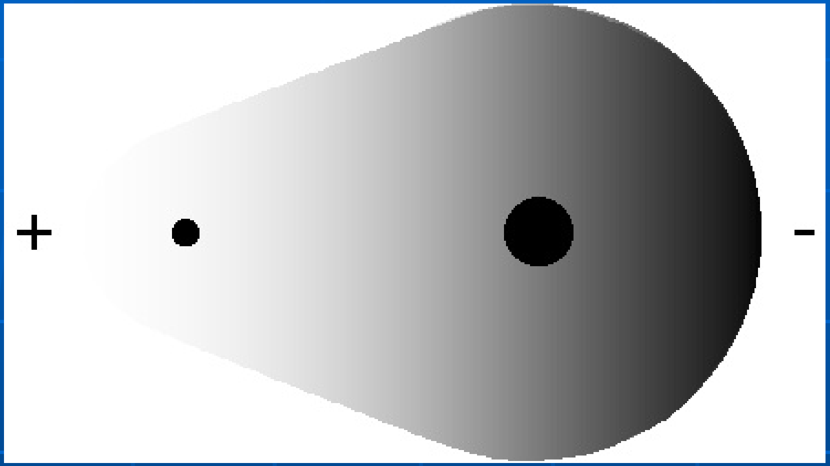


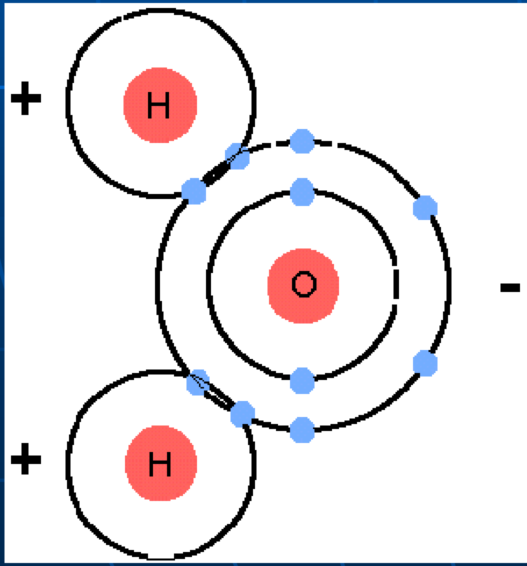
- Ionic bonding is the transfer of electrons from one atom to another.
- Atoms that have lost or gained electrons are called ***ions***.
  - + = Cations
  - - = Anions

Ionization



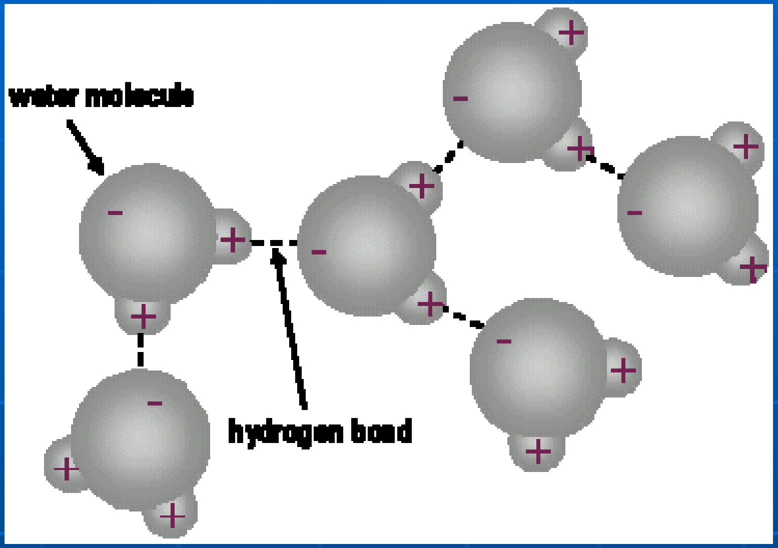
H-Deuce-O

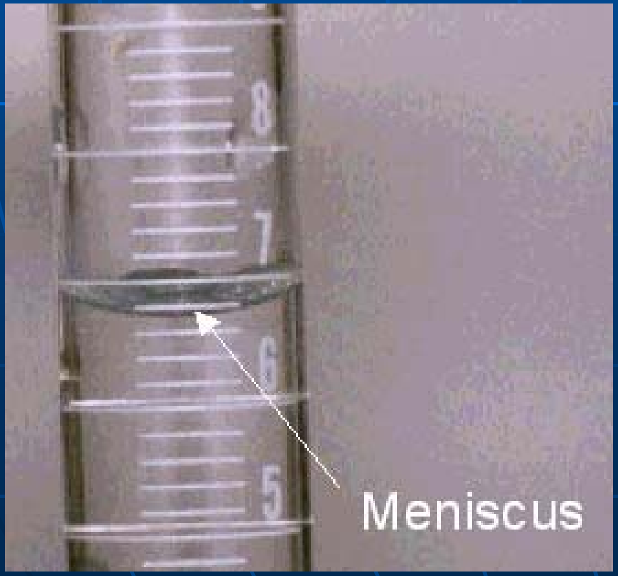




- Polar
- Covalent
  - Shares electrons, doesnt lose or gain
- Molecule

Big prop's





- Solvent
- High surface tension
- 'Water bugs'
- Action is independent of volume

Sorry, Its not that simple…

- Review
  - Water types
  - Water properties
  - Solutes – bits in the water

Cations – Positive

- Most widely occurring cations in water
  - Ca >> Mg > Na >> K >> Mn
- Ca
  - ***Principle mineral hardness***
  - ↓ mash pH, enzyme activity, protein digestion, lauter runoff
  - Neutralizes toxic substances in yeast: Peptone & Lecithin
  - inverts malt phosphate to pp alkaline phosphate
- Mg
  - 2ndary mineral in hardness
  - accentuates bitterness
- Na
  - Accentuates beer flavor

Anions - Negative

Strong vs Weak Buffers

$CO_3 >> SO_4 >> Cl$

- CO_3^{2-} - Carbonate
  - ***Contributes most of alkalinity***
- $CO_3^{2-} + H_20 \rightarrow HCO_3^- +$ **OH^-**
  - Pulls H^+ from $H_20 = OH^-$
  - STRONG alkaline buffer = neutralizes acids
    - Resists ↓ mash pH
  - ↓ α-amylase activity, cold break,
  - >200ppm = NEEDED dark roast grains to buffer
- SO_4^{2-} - Sulfate
  - Weak buffer
  - >150ppm = cleaner, more pleasant bitter
- Cl^- - Chloride
  - Very weak buffer

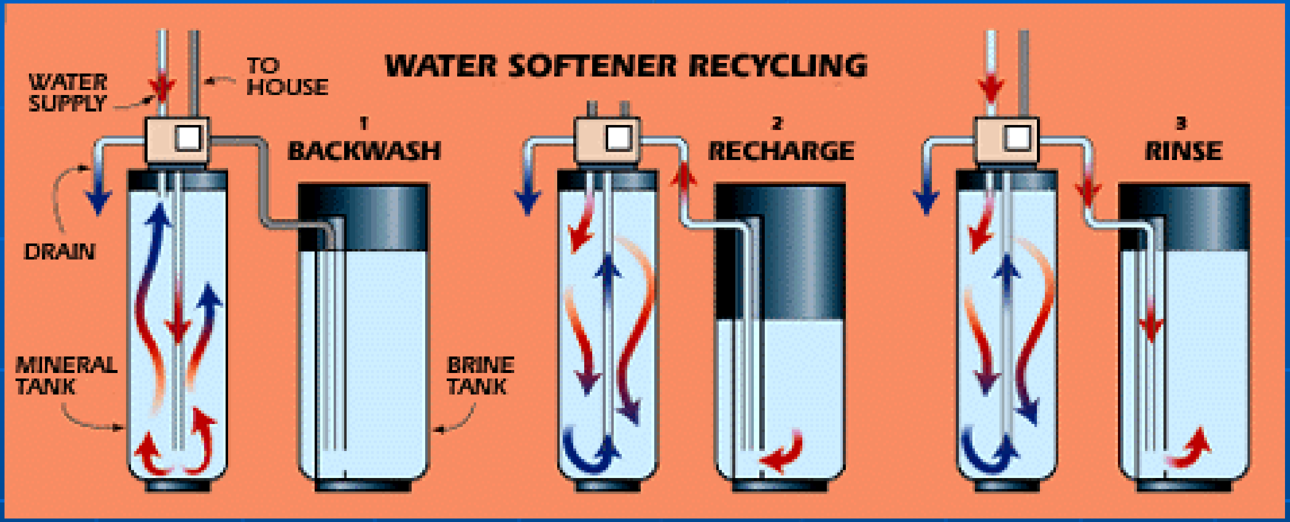
Complicated??

- Ca – ↓ mash pH
- CO3 – buffers mash pH
  - resists changes in mash pH
  - neutralizes acid

Hard vs Soft: The other definition

- Old Skizool nomenclature: Ability to form a lather with a bar of soap??
  - Hard: Buncha stuff
  - Soft: notta so much stuff

Water Softener



- Exchanges Na for Ca and Mg
  - Ca/ Mg precipitate out in pipes
  - ‘Scale’ or ‘Beer Stone’
- Bypass!!!

hAHdness

$CaCO_3$ Hardness
Soft 50ppm → Hard 300ppm

- Ca & Mg in water
  - Inhibit lather of soap = ‘hard’
  - Slightly acidic = weak bonds
  - Combine with CO_3^{2-}, SO_4^{2-}
    - PP as insoluble mineral salts
- Temporary vs. Permanent
  - Temp = carbonate hardness
    - part of hardness that will pp after boiling
  - Permanent
    - Ca/Mg w/ non-carbonate ions

Alkalinity

Alkalinity

- buffering capacity of dissolved ***anions***
- HCO_3^- (bicarbonate) ~ CO_3^{2-} → <u>ONLY</u> significant factor

Accepted standard – CaCO3??

- expresses hardness and alkalinity together
- Ca – primary mineral of hardness
- CO3 – principle cause of alkalinity

MEHHHH!!??

- Alkalinity > hardness → hardness is <u>TEMPORARY</u>
- Hardness > alkalinity → <u>PERMANENT</u> SO_4 hardness

Rho to the H!!

Concentration of Hydrogen ions compared to distilled water		Examples of solutions at this pH
10,000,000	pH= 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vineger
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Acid rain Tomato Juice
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine Saliva
1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH =13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

BEER!!!

pH

- Measure of acid (H+) to alkaline (OH-) ratios of a solution
- pH values run from 1 to 14
  - negative log10 of [H+]
  - 0 (highly acidic) to14 (highly basic), 7 neutral

Das pH boot camp

- Log scale
  - pH = $-\log_{10}$ [H+]
  - By 10's
  - Calculation
    - Change pH from 7 to 5
    - $10^{-7} \rightarrow 10^{-6} \rightarrow 10^{-5}$
      - 10^2 = 10x10 = increase [H+] = 100 fold

- **HCl**(aq) [**H**+] = 0.01 = pH2
- **Distilled H2O**(l) [**H**+] = 0.0000001 = pH 7
- **NaOH**(aq) [**H**+] = 0.00000000000001 = pH 14

- **The more acidic the solution, the lower the pH value;**

- Conversely: **the pH value rises as the solution becomes more alkaline.**

pH in Brewing

- ***pH in Brewing***
- prerequisite of brewing cycle!!
  - Enzyme activity, kettle break, yeast performance, hop extraction, clarification (flocculation)
- ***Target pH***
  - pH 5.2 – 5.5 – saccrification
  - pH 5.0 = protein degradation
  - pH 5.5 = amylase
  - pH 6.0 = reduce enzymatic activities, ***extracts tannins***

Malt pH

- Distilled H2O = NO ions
  - 100% base = pH 5.7 - 5.8
  - Caramel/crystal = pH 4.5 – 4.8
  - Chocolate = pH 4.3 – 4.5
  - Black/RB = pH 4.0 – 4.2

Water Treatment

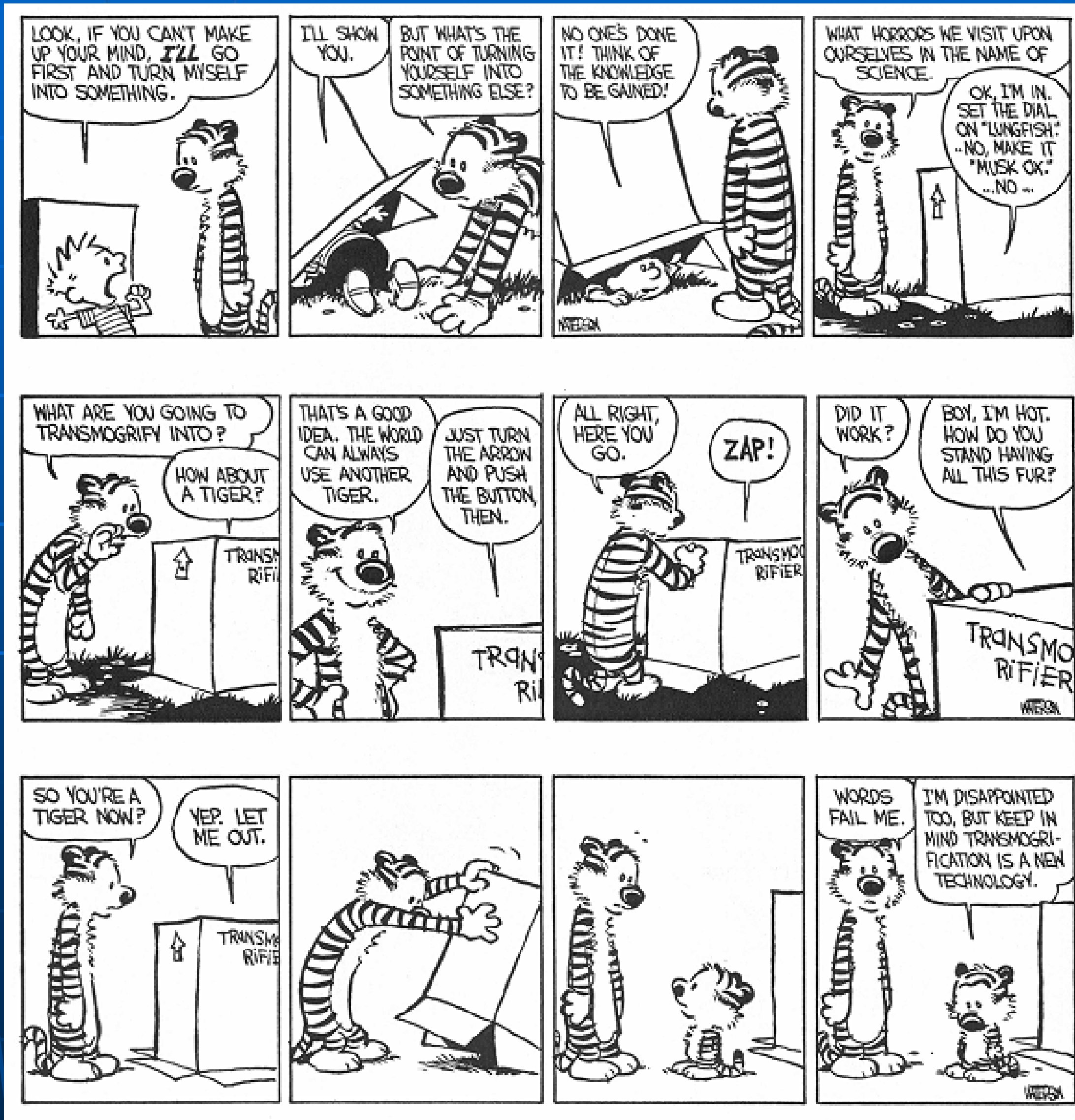
- ↓ pH = MOST common
- ↓ HCO3??
  - Boil
    - PP out organic salts in boil
    - $CO_2 + H_2O \rightleftharpoons$ **H_2CO_3**
    - **H_2CO_3** $\rightleftharpoons HCO_3^- +$ **H^+**
  - Roast malts
    - Acid is created over high kiln temperatures
    - Dublin
  - Add acid
    - Phosphoric acid
      - $H_3PO_4 + CaCO_3 \rightarrow$ **H_2CO_3** + **$CaHPO_4$ pp**
    - Lactic acid
      - $2C_3H_6O_3 + CaCO_3 \rightarrow$ **H_2CO_3** + **$Ca(C_3H_5O_3)_2$ pp**

Summarizationizzal

- IMPORTANTE!!!!
- Types aqua
- Chemstry
- Ions
- pH
  - Adjustments

Transmogrification

- Brewing centers
- Specific water
- Salt Additions
- Recreations!!



Brewing Capitals

How much do you know???

Beer central

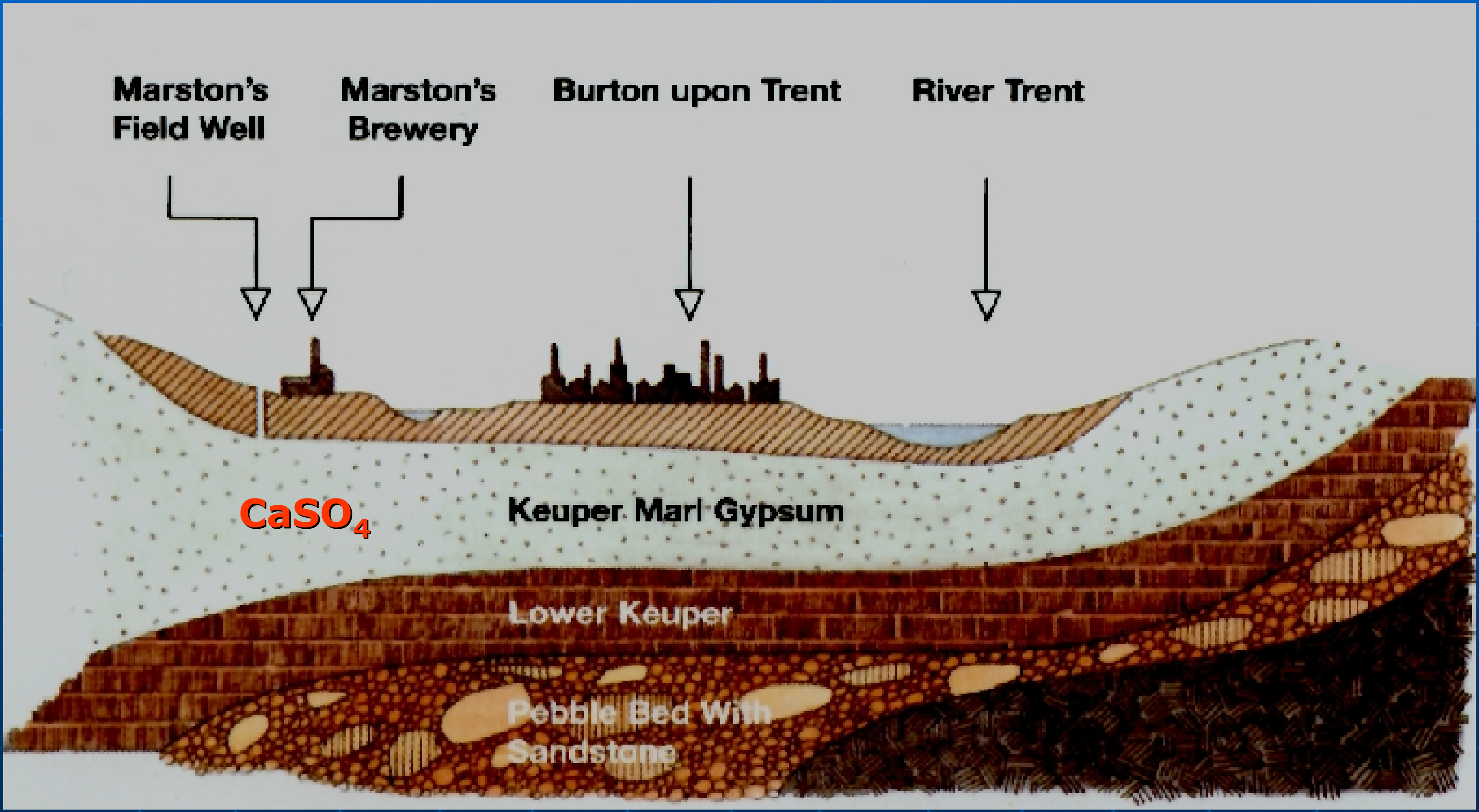
1. Pilsen
2. Munich
3. London
4. Dublin
5. Edinburgh
6. Köln

1. Softest brewing water – pale and clean beers
2. High Carbonates – low hops, high color and malt
3. High Carbonates – smooth dark ales
4. VERY VERY high Carbonate levels – acidic dark malts needed for mash pH
5. similar to London's, more bicarbonate and sulfate, lends heavier malt body
6. Soft, low levels of calcium, magnesium, bicarbonates. Lends delicate impression.

Rock Formations

- Non-reactive
  - Granite, Sandstone
    - ~90% Silica (SiO_2)
- Reactive
  - Lime Stone ($CaCO_3$)
  - Dolomite ($CaMg(CO_3)_2$
  - Gypsum ($CaSO_4$)

Specific locations



Blessed waters

- Brewing city, check! …specific water???

Water Salts: Stick the what in the where now??

	Pilsen	Munich	London	Vienna	Dublin	Dortmund	Burton
Calcium	7	75	52	200	118	225	268
Magnesium	2	18	16	60	4	40	62
Sodium	2	7	99	8	12	60	54
Chloride	5	10	60	12	19	60	36
Sulfate	5	10	77	125	54	120	638
Alkalinity	14	152	156	120	319	180	200

Exact!?

- Only worry is solubility!
- Don’t have to be exactly accurate
- Mother Nature
  - Not same stuff we have

Stick the what in the where now??

- ***Key ideas***
  - WEIGH, WEIGH, WEIGHT - DON’T use volumes e.g. NO tsp
  - Add to water then to mash, NOT directly
- CaCO3 – Calcium carbonate (chalk)
  - Buffers mash acidity
  - Partly pp in kettle
- CaSO4 – Gypsum
  - ↓ pH = pp CaPO4
- MgSO4 – Epsom salts
  - ↑ Mg & SO4
- Ca(OH)2 – Slaked lime
  - ↑ pH = pp CaCO3

Tasting!!!

- Taste the water
  - Get a 'feel' for it
  - Slosh it around
- Sip distilled water for rinse
- Taste the beer
  - Think about the 'flavor', mouthfeel
- Repeat
- Compare the water with the beer

Order

1. Edinburgh
    1. Balhaven Scottish
2. Köln
    1. Reissdorf kölsch
3. Munich
    1. Hacker-Pschorr Ofest
4. London
    1. Fullers London Pride
5. Plzeň
    1. Pilsner Urquel
6. Dublin
    1. Guinness

Water Analysis

SOURCE	Ca	Mg	Na	CO3	SO4	Cl
Antwerp [DeKonick]	90	11	37	76	84	57
Beerse region [Westmalle]	41	8	16	91	62	26
Brugse [Brugs Tarwebier]	132	13	20	326	99	38
Brussels region	100	11	18	250	70	41
Burton-upon-Trent 1	268	62	-	280	638	36
Burton-upon-Trent 2	270	60	30	200	640	40
Burton-upon-Trent 3	295	45	55	300	725	25
Burton-upon-Trent 4	268	62	54	200	638	36
Dortmund 1	225	40	60	180	120	60
Dortmund 2	250	25	70	550	280	100
Dublin 1	119	4	12	156	53	19
Dublin 2	118	4	12	319	54	19
Düsseldorf	40	-	25	-	80	45
Edinburgh 1	140	60	80	140	96	34
Edinburgh 2	120	25	55	225	140	20
Edinburgh 3	100	18	20	160	105	45
Köln (Cologne)	104	15	52	152	86	109
London Well 1	52	32	86	104	32	34
London Well 2	50	20	100	160	80	60
Munich 1	75	18	2	150	10	2
Munich 2	109	21	2	171	79	36
Munich 3	75	18	-	152	10	2
Pilsen	7	2	2	15	5	5
San Francisco [Anchor]	24	15	28	104	39	39
Vienna 1	200	60	8	120	125	12
Willebroek/Rumst [Duvel]	68	8	33	143	70	60