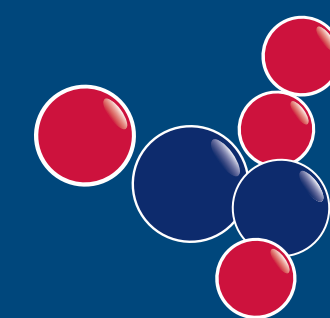


Application of Ion Exchange in Wastewater Treatment

Bill Koebel
3/6/2019

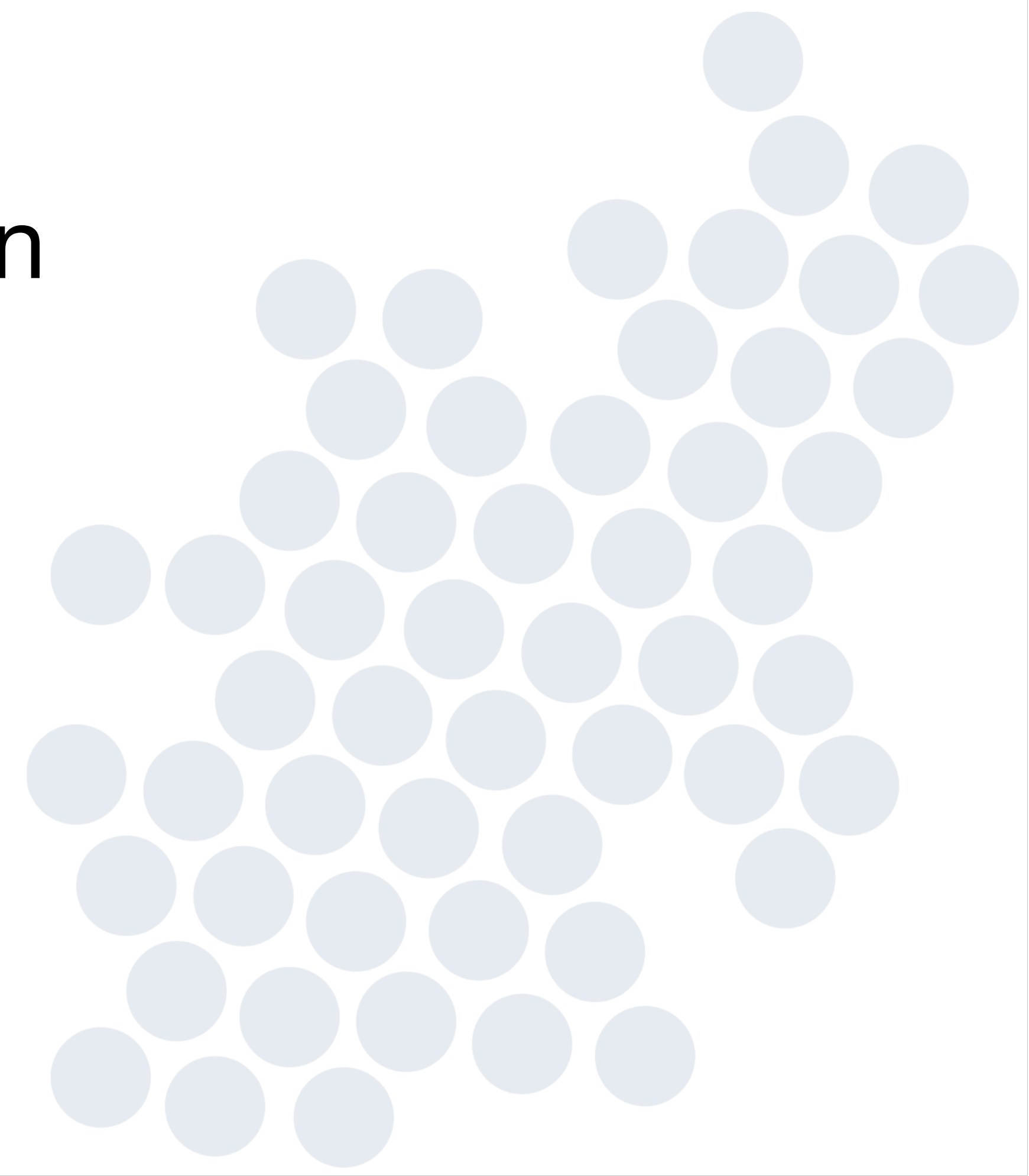


RESINTECH[®] INC.

INNOVATIONS IN ION EXCHANGE



Topics of Discussion

- Understanding “Metals” in Water
 - How Ion Exchange Works- Short Version
 - Resin Type Review
 - What We Need to Know
 - Basic Application Review
 - Q & A
- 

Metals in Waste Water

- Is what you want to remove cationic or anionic?
- Are the metals soluble or insoluble?
 - pH dependent (hydroxide solubility)
 - Other chemistry can complex
 - Filtered vs Unfiltered Results
- Analysis data doesn't always tell the whole story.

Yes, the Periodic Table

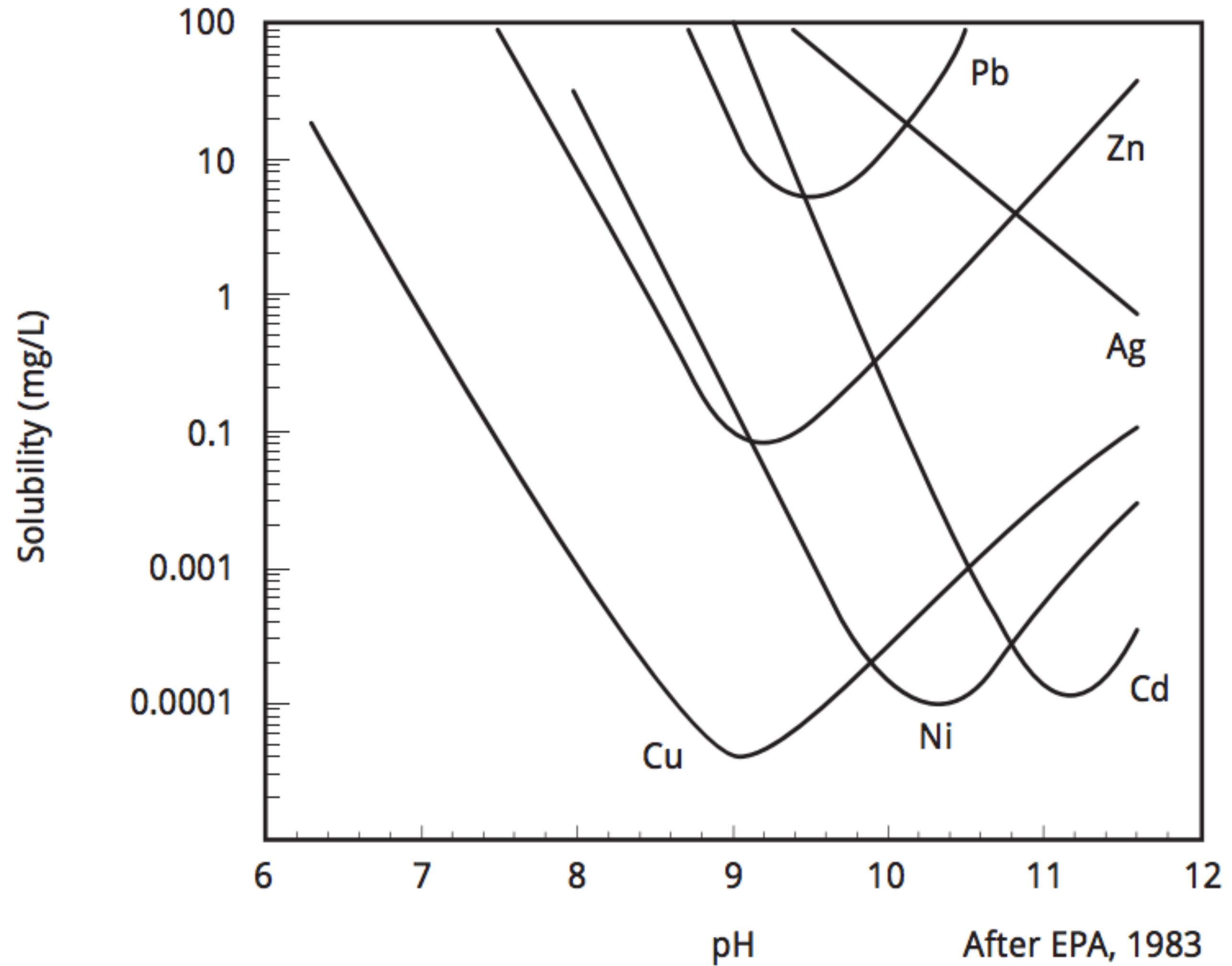
Periodic Table of the Elements

1 IA 11A H Hydrogen 1.008	2 IIA 2A He Helium 4.003																	18 VIIIA 8A
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180	
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948	
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.09	35 Br Bromine 79.904	36 Kr Krypton 84.80	
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29	
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018	
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown	

Lanthanide Series	57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

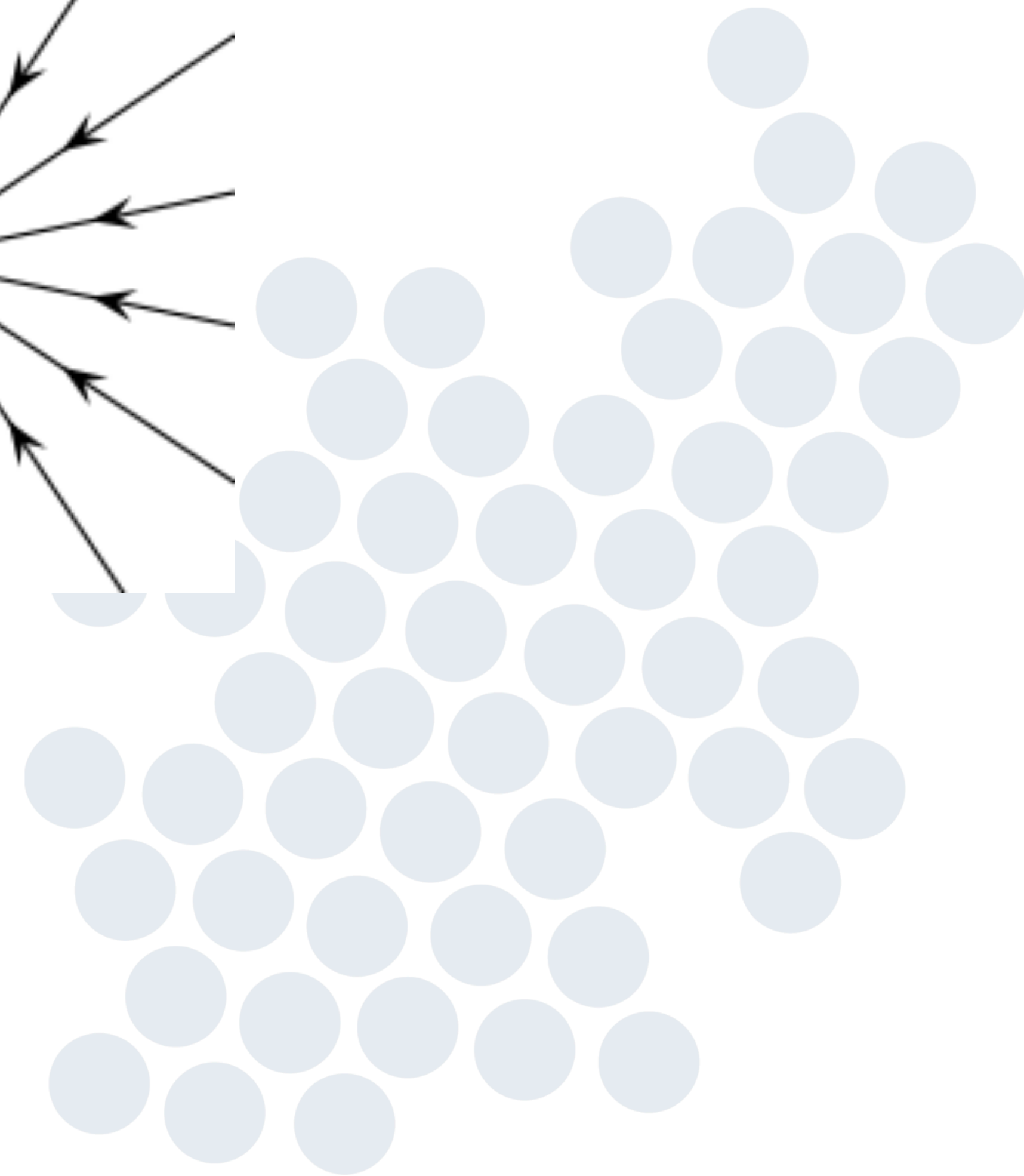
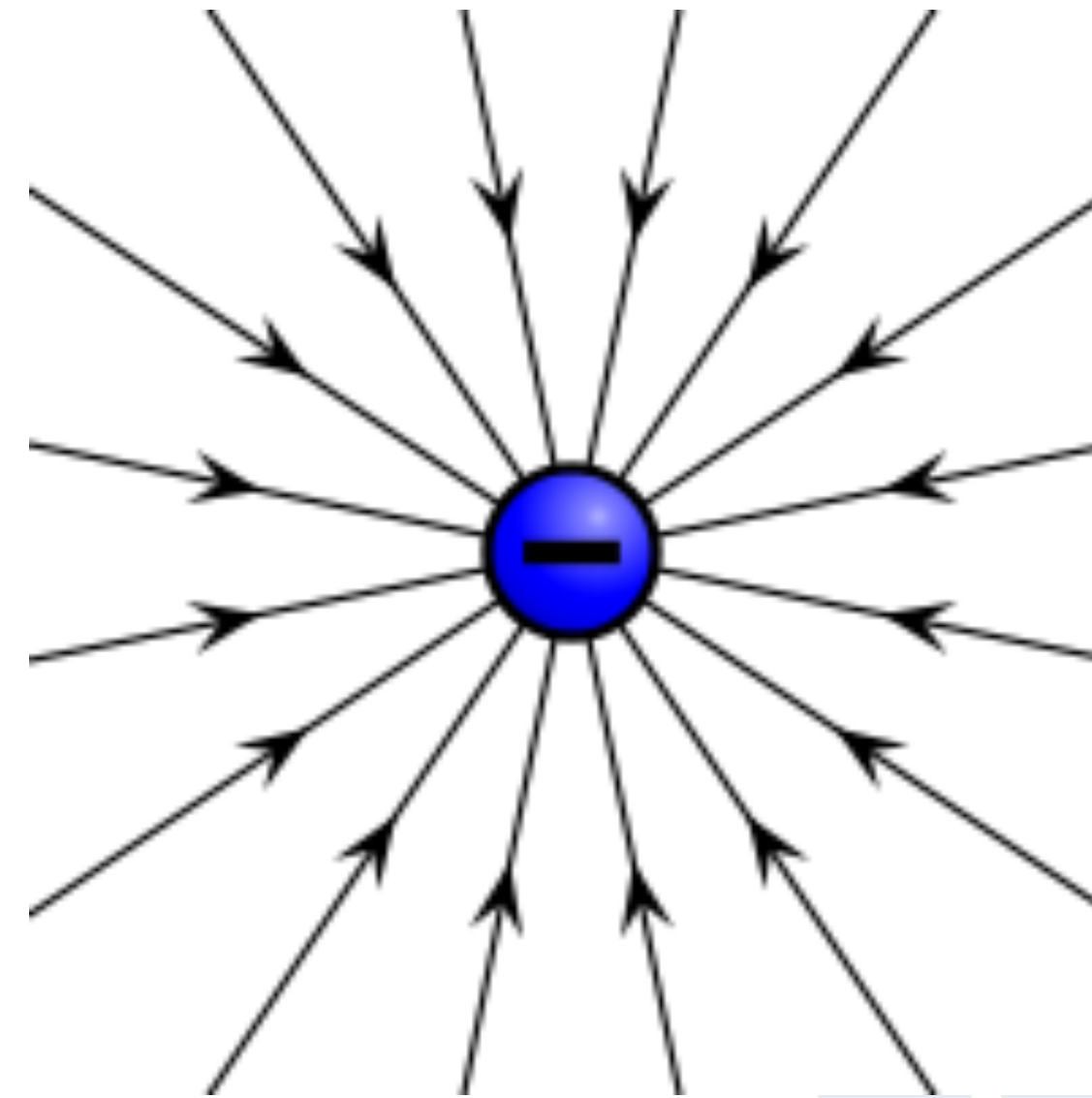
Alkali Metal	Alkaline Earth	Transition Metal	Semimetal	Nonmetal	Basic Metal	Halogen	Noble Gas	Lanthanide	Actinide
--------------	----------------	------------------	-----------	----------	-------------	---------	-----------	------------	----------

Metal Hydroxide Solubility




Common Anionic Contaminants

- Arsenic
- Antimony
- Chromate (Hex)
- Uranium
- Cyanide
- Perchlorate
- Nitrate





Ion Exchange Today

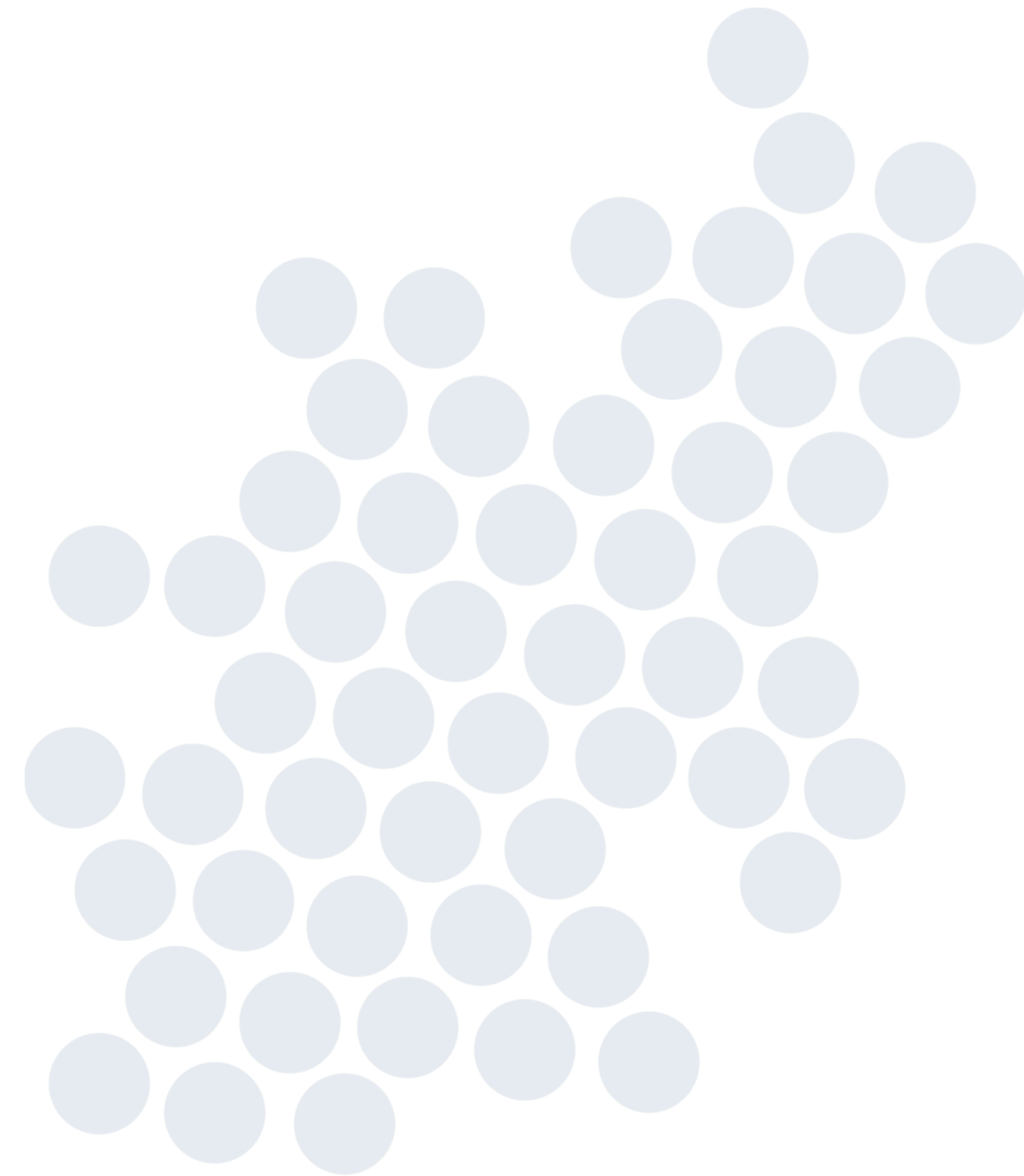
- Tiny plastic beads that have been chemically activated
 - They are manufactured products that are made from petrochemical based monomers
- 

Ion Exchange Today



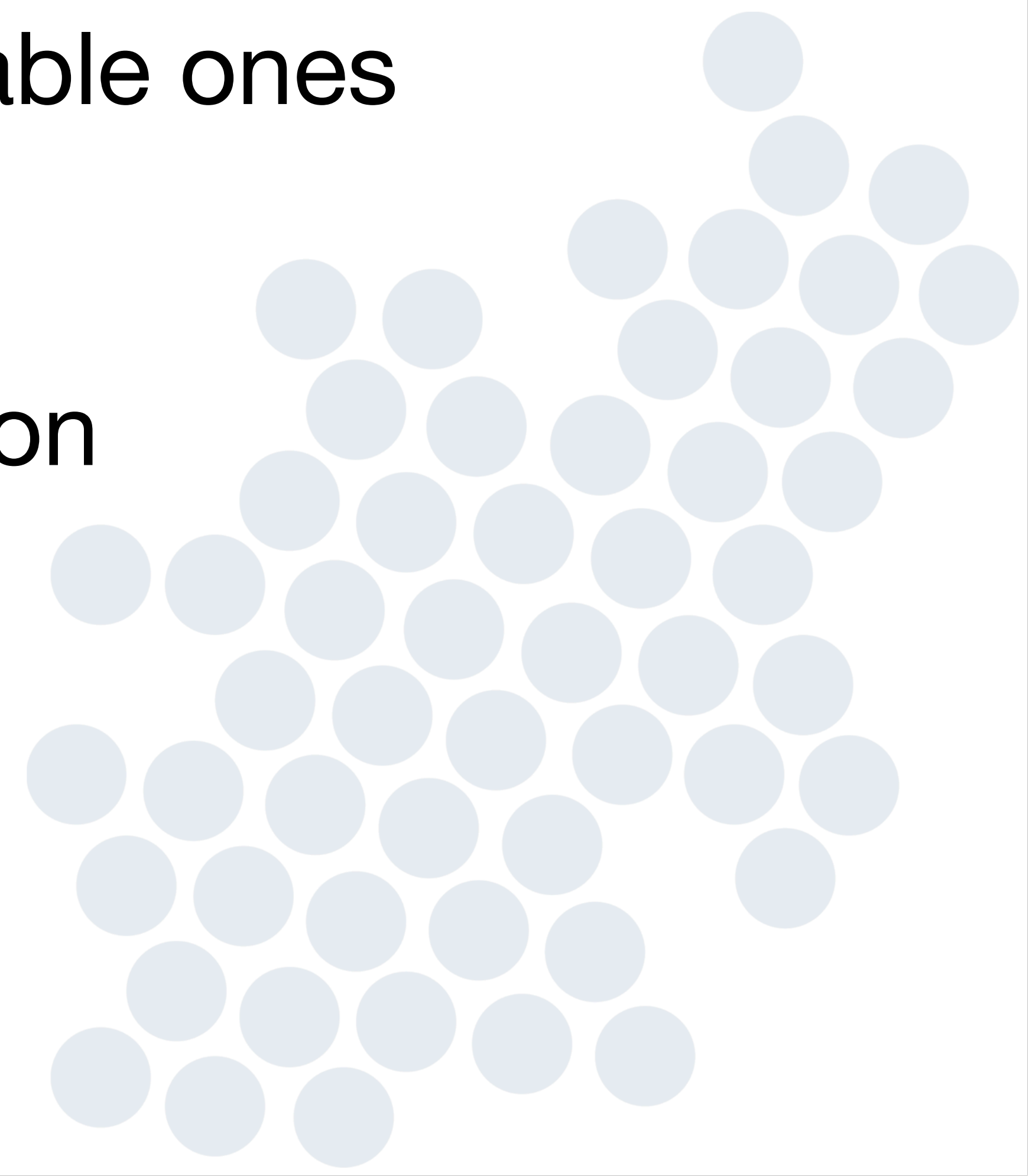
Material Properties

- Size between 16 to 50 U.S. Mesh
- Resistance to fracture
- Insoluble
- Permanently attached sites
- High capacity for ions
- Temperature effects negligible

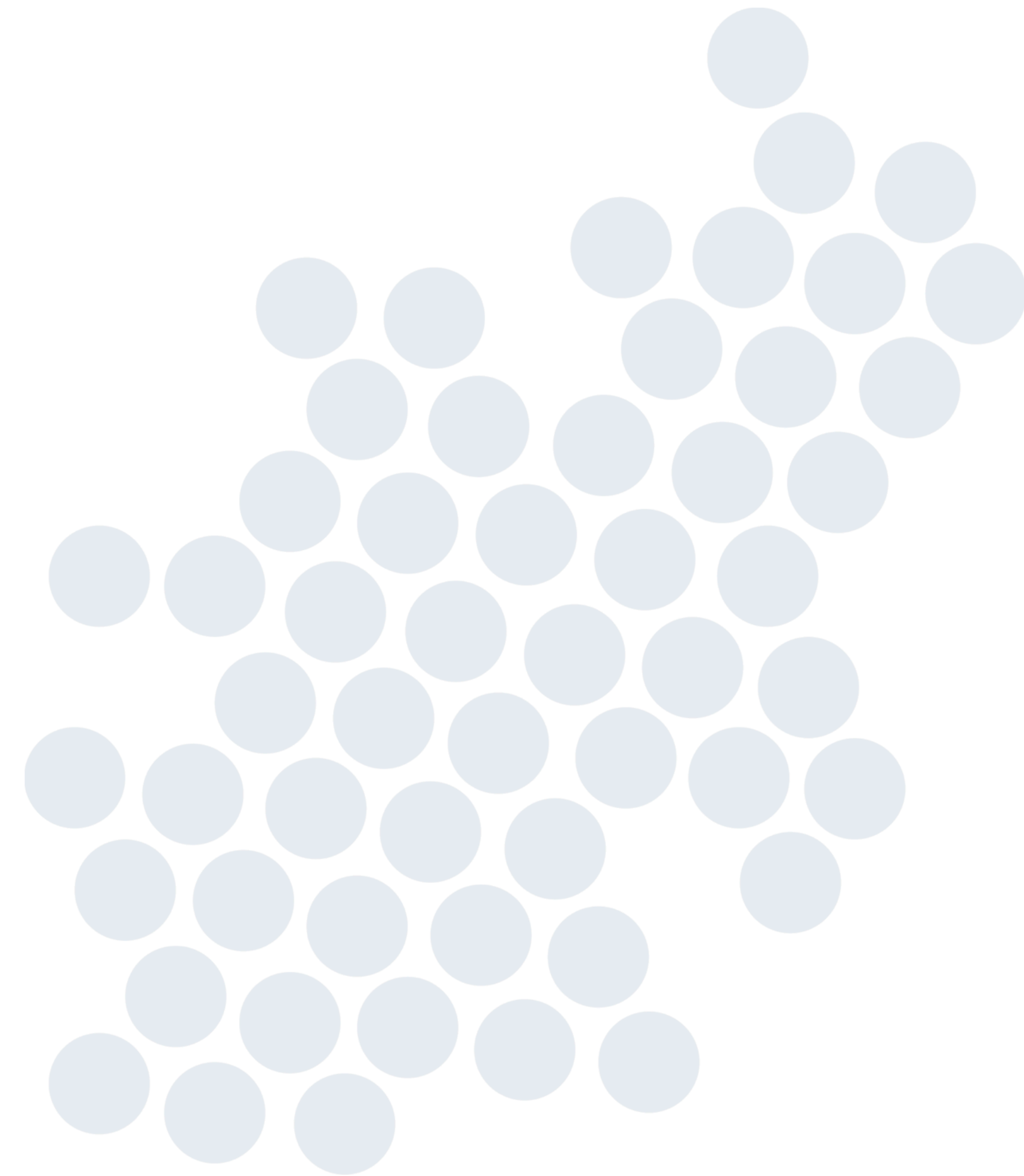
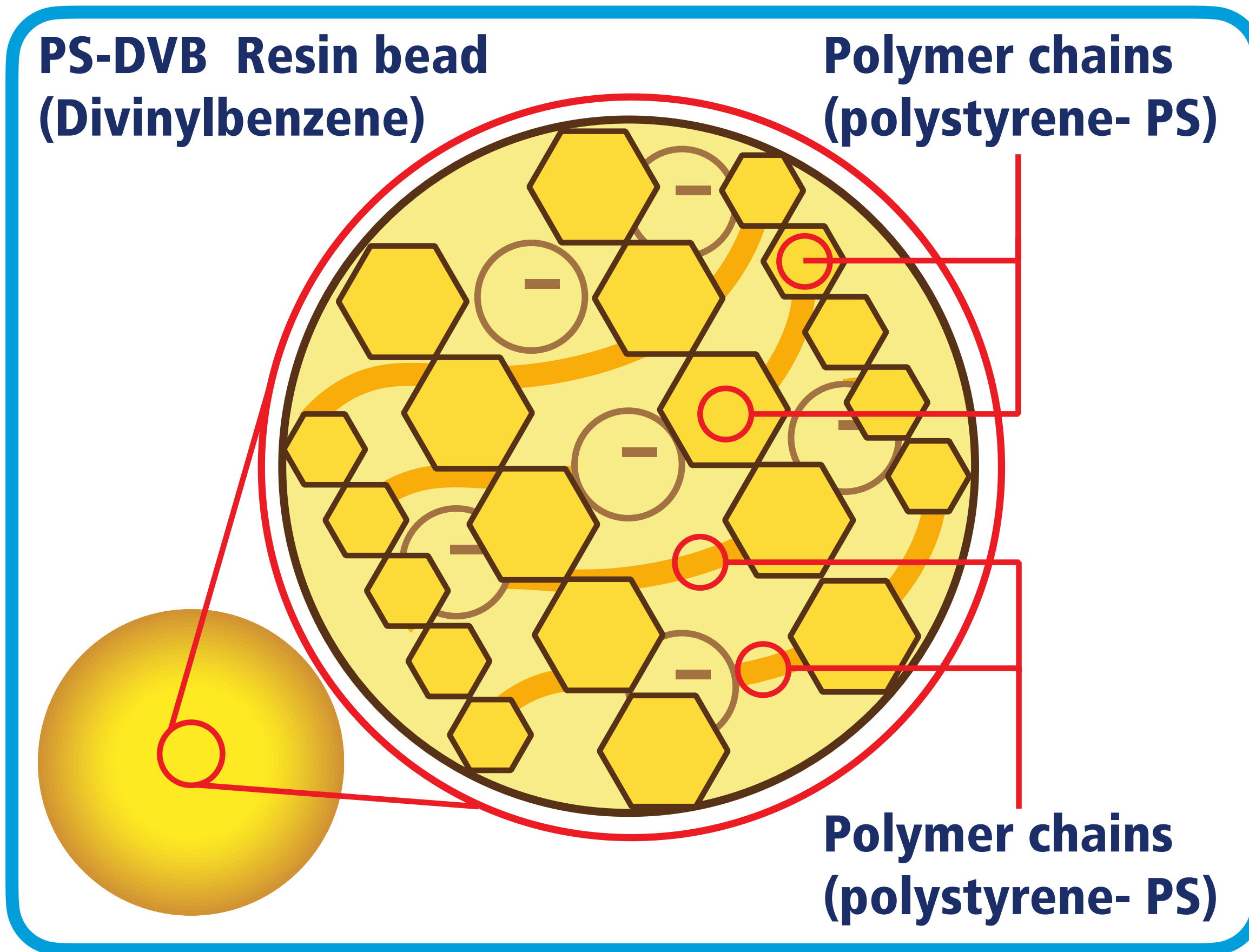




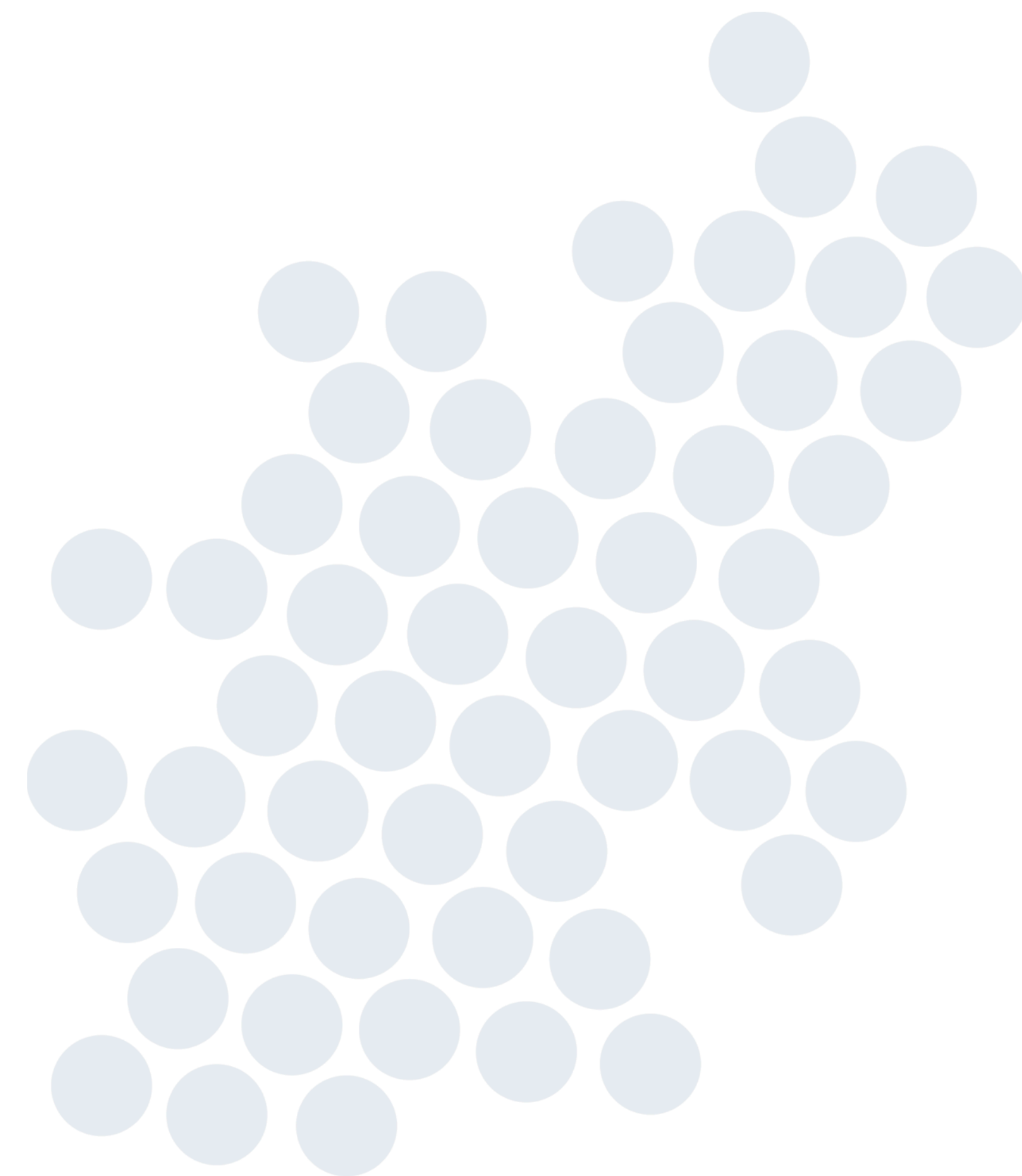
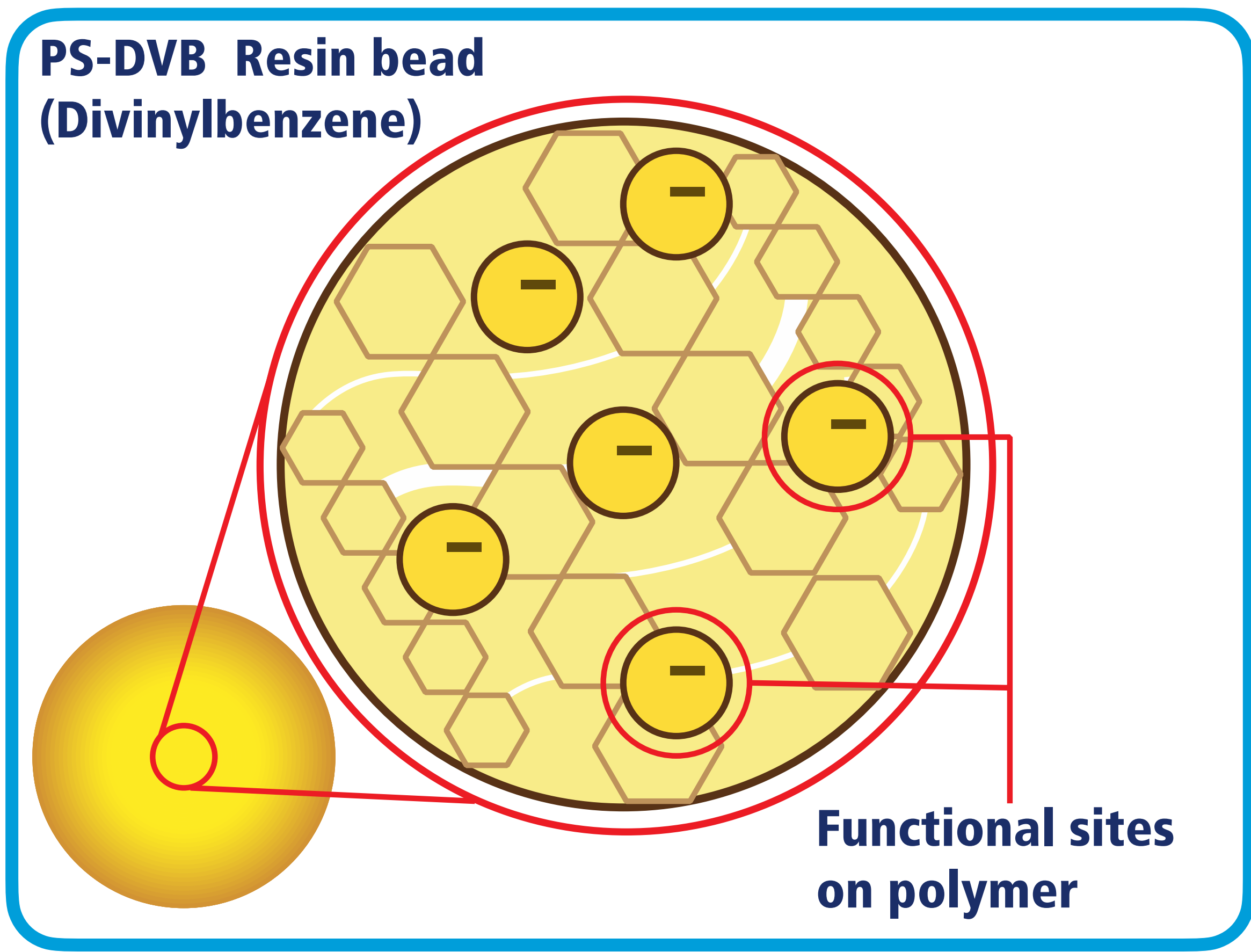
What is Ion Exchange?

- Exchange of undesirable ions for desirable ones
 - Selectivity drives the reaction
 - The process is reversible via regeneration
- 

Inside the Resin Bead

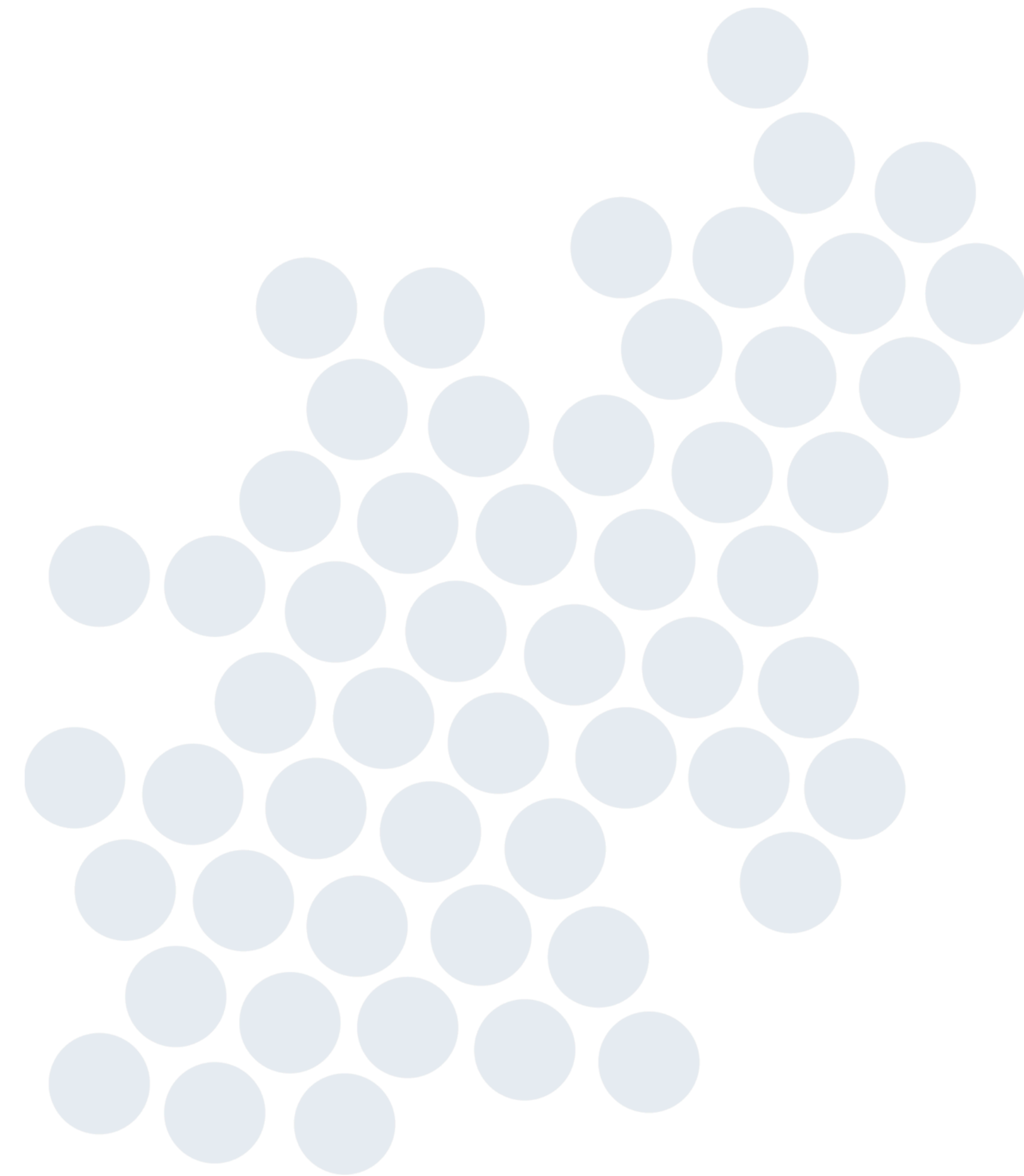
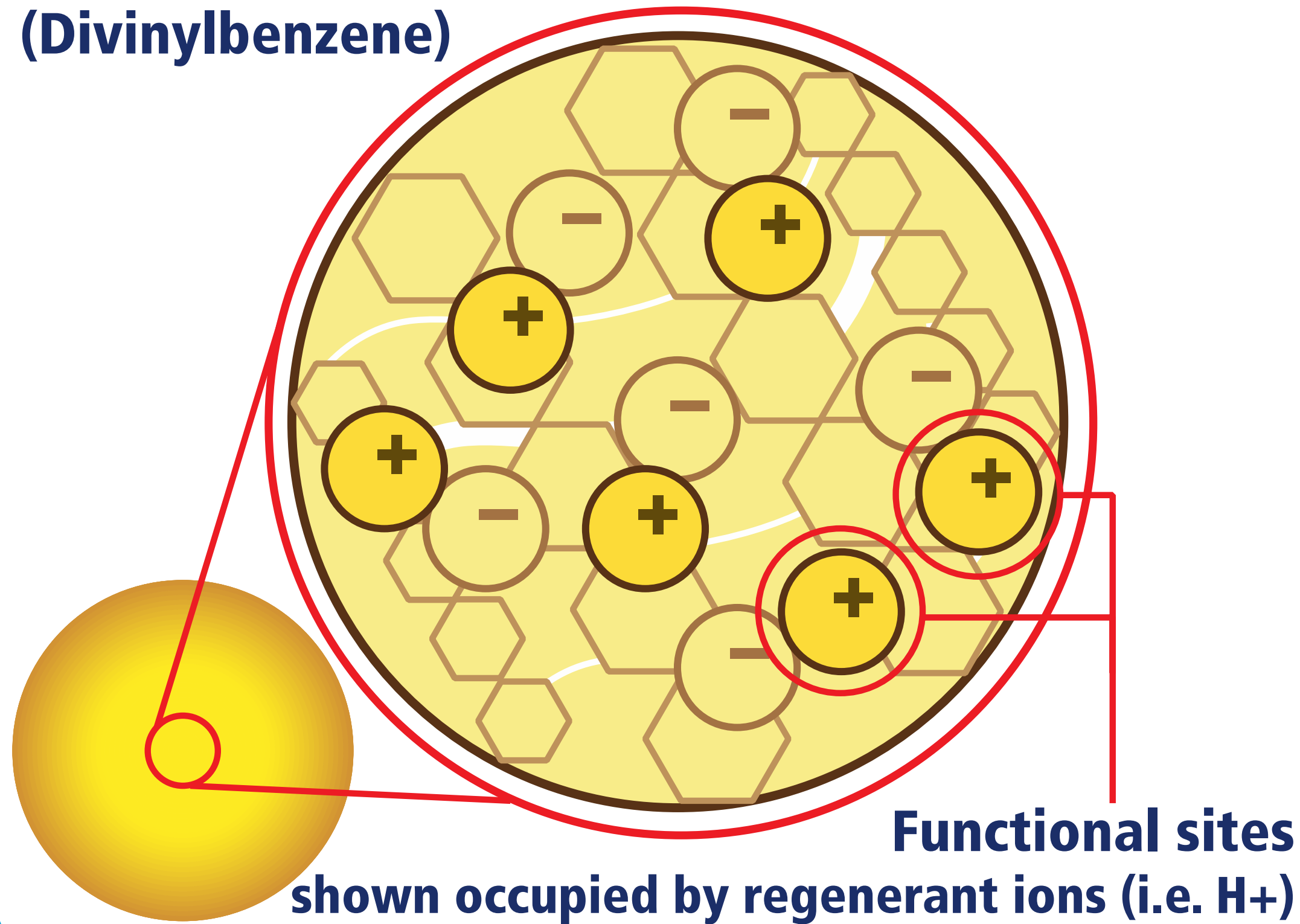


Inside the Resin Bead



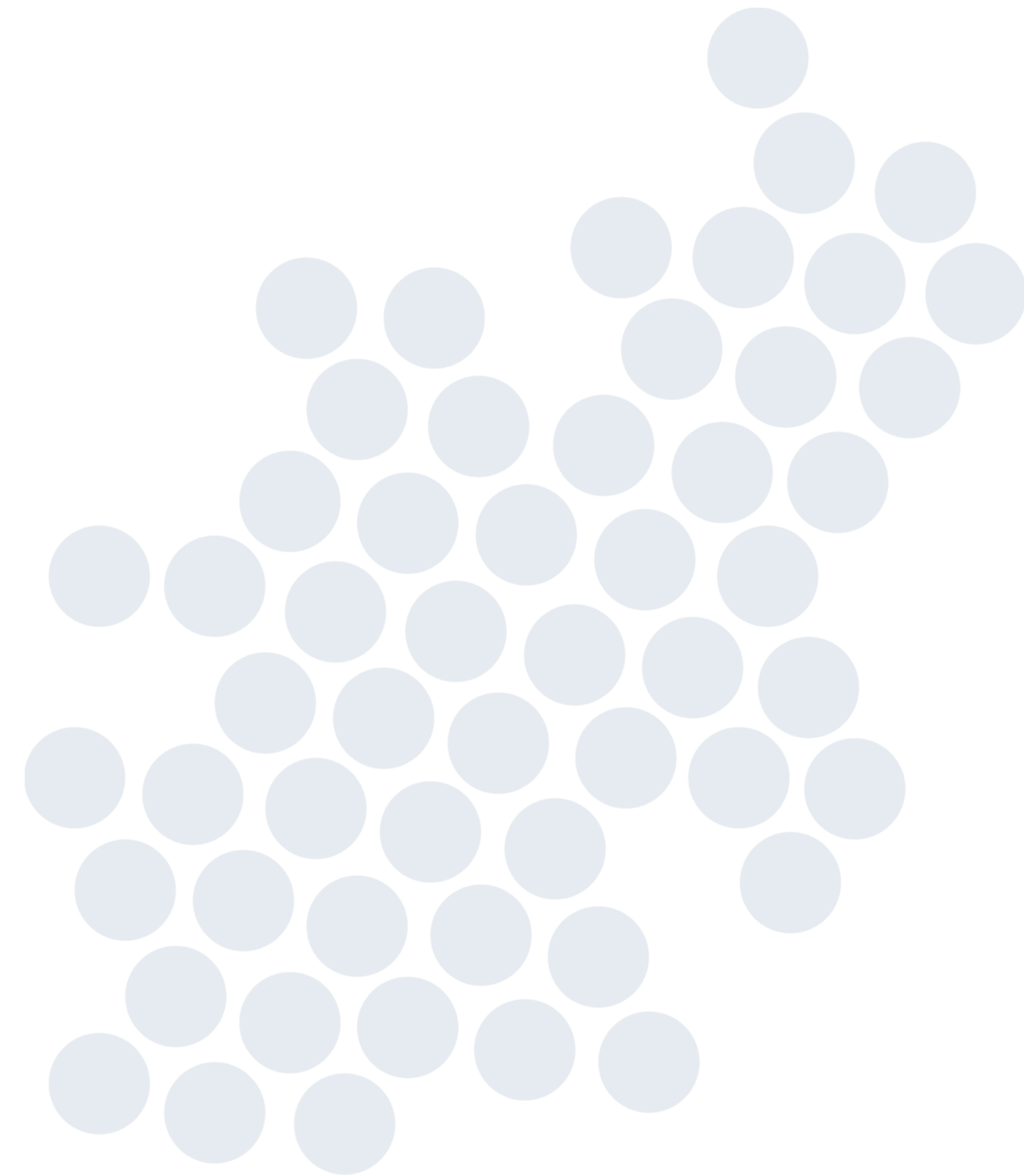
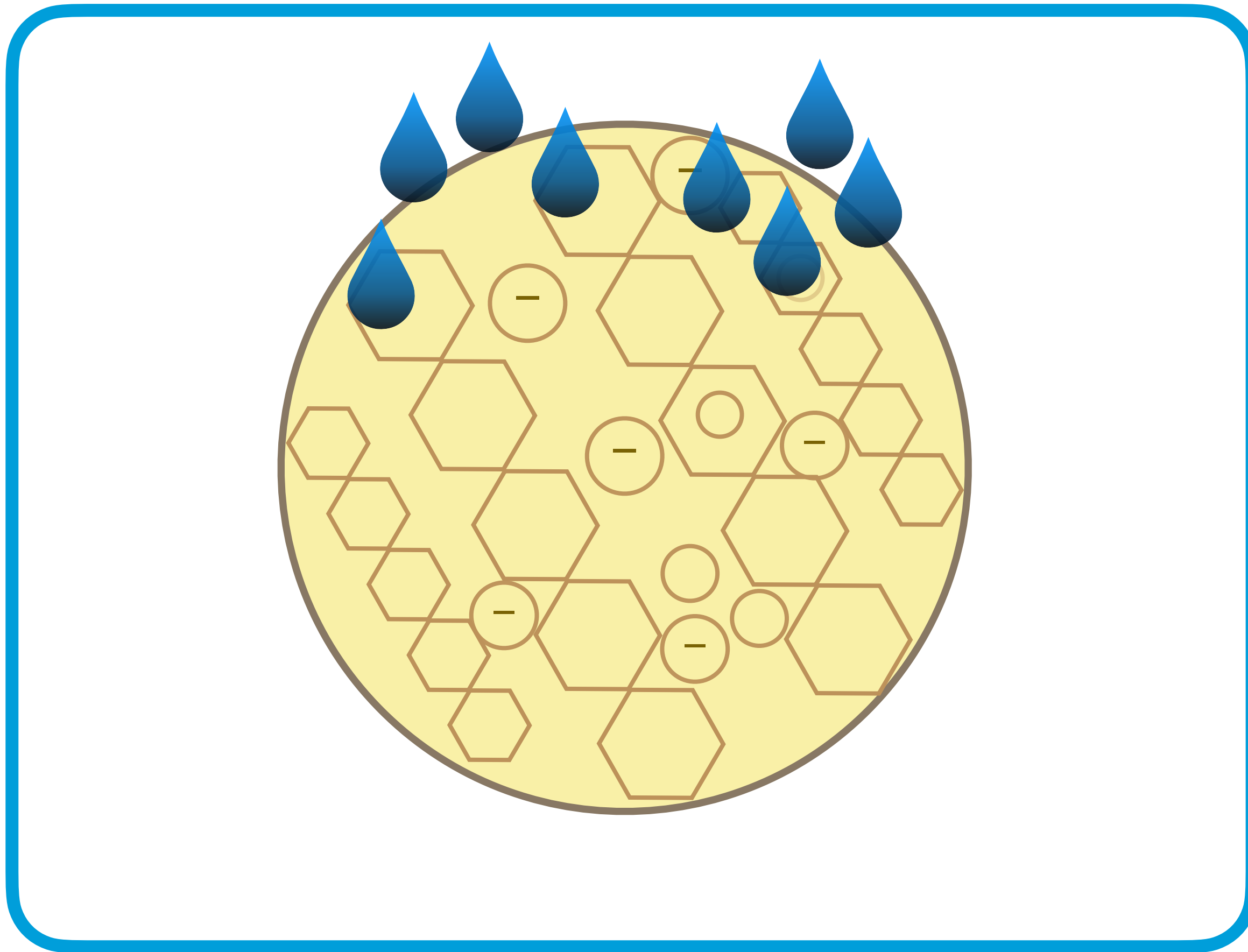
Inside the Resin Bead

**PS-DVB Resin bead
(Divinylbenzene)**



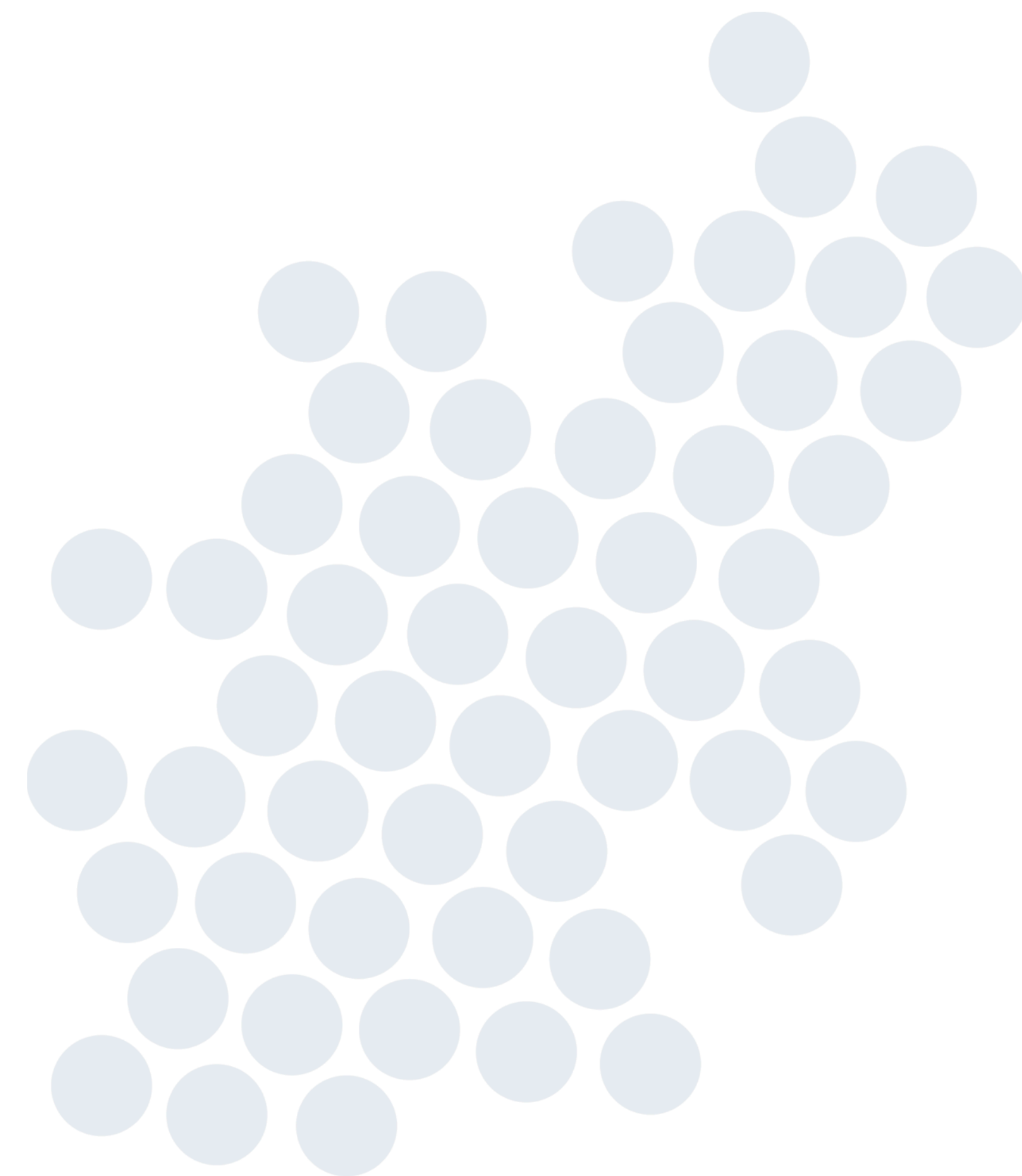
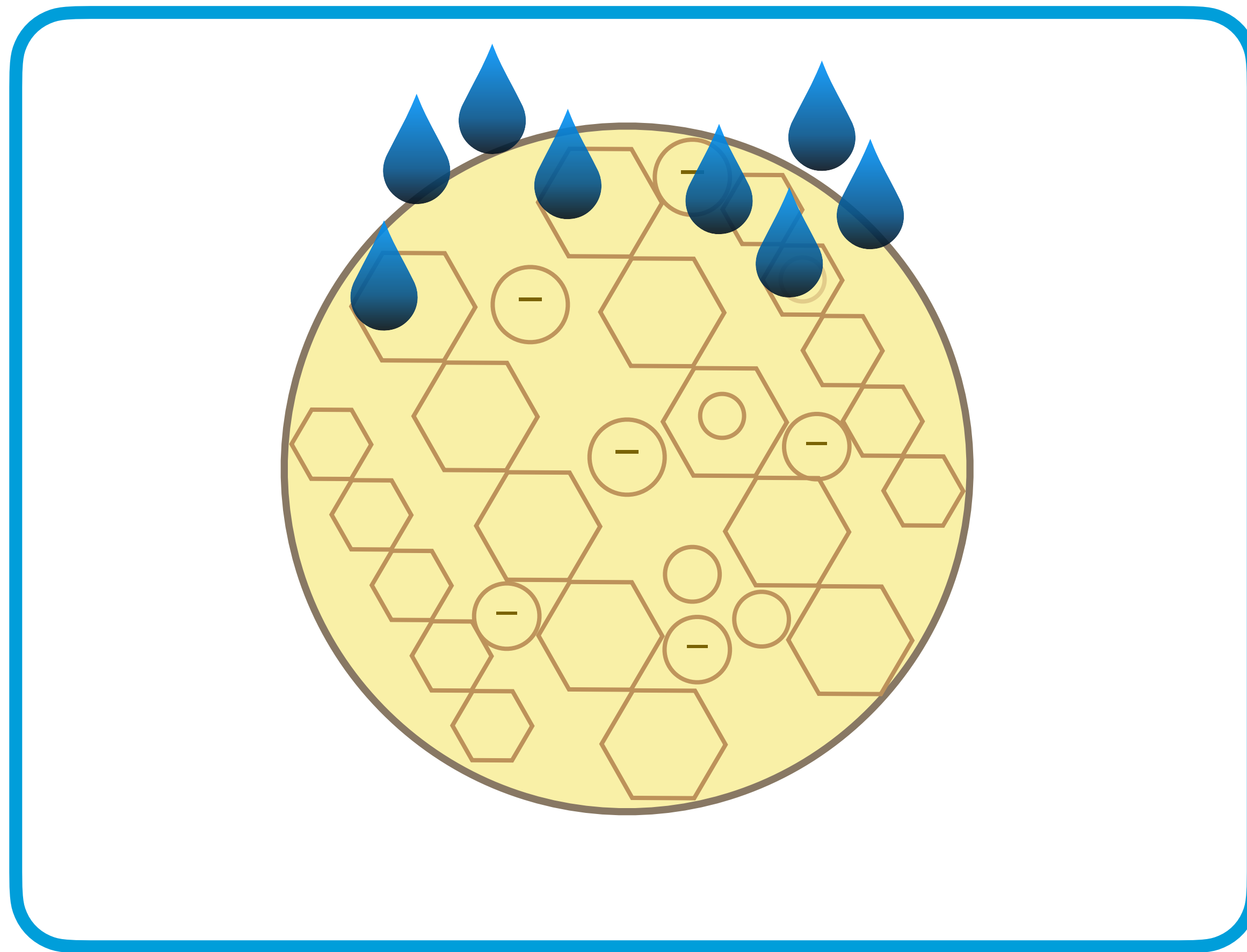
The Resin Bead in Action

Water contacts resin beads. Beads are 50% water.



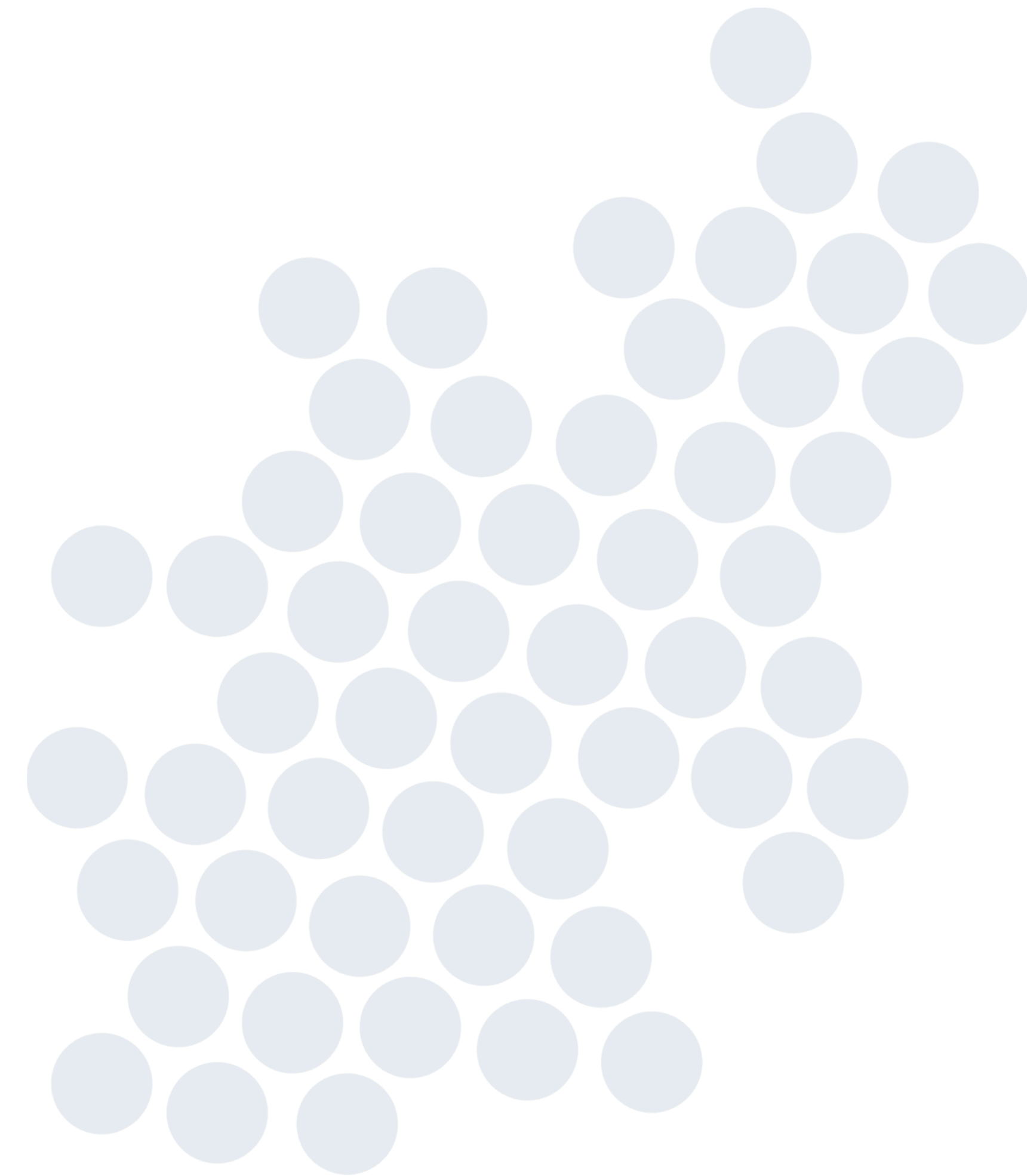
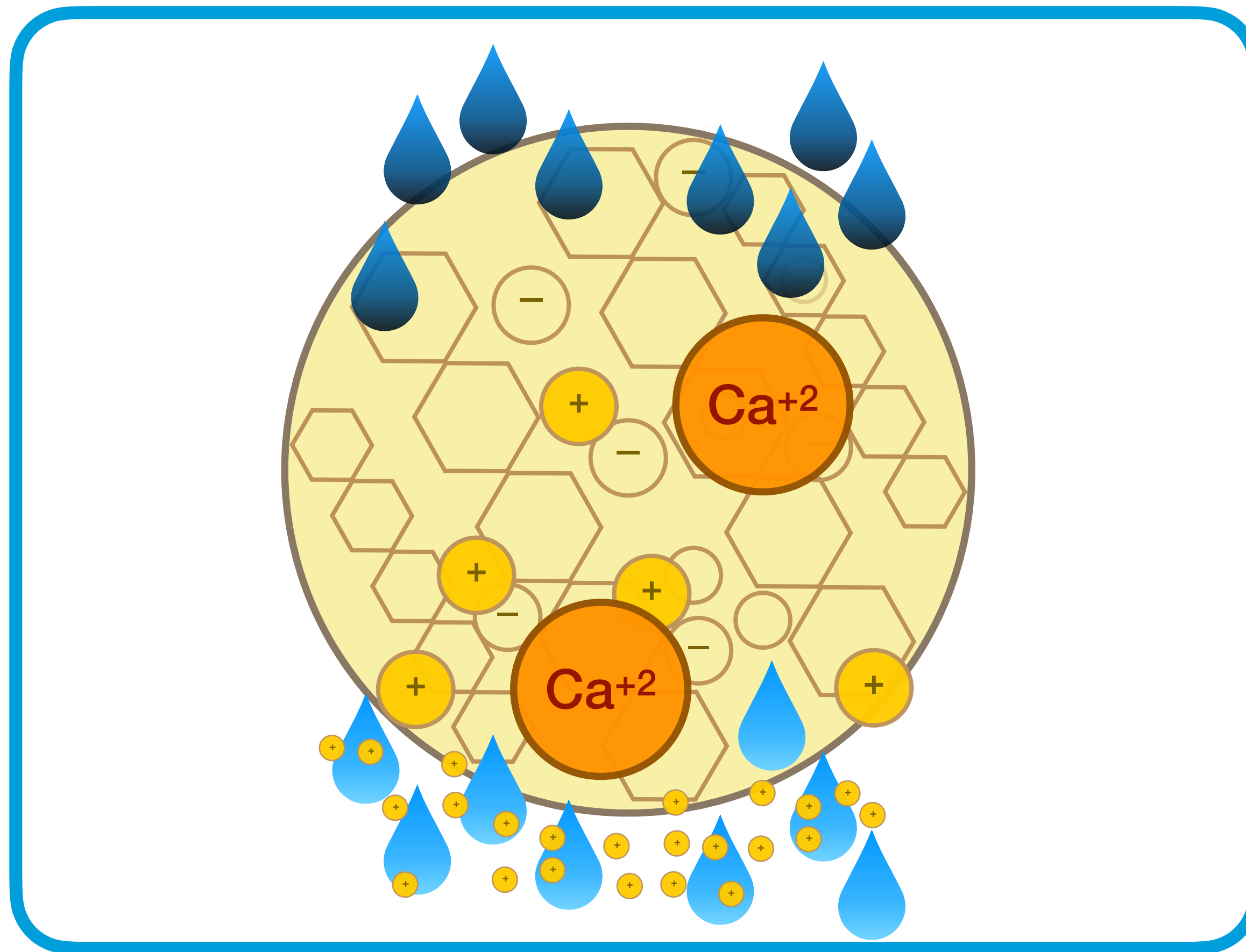
The Resin Bead in Action

Water containing unwanted ion, in contact with water inside beads, allows ions to diffuse in/out of beads.



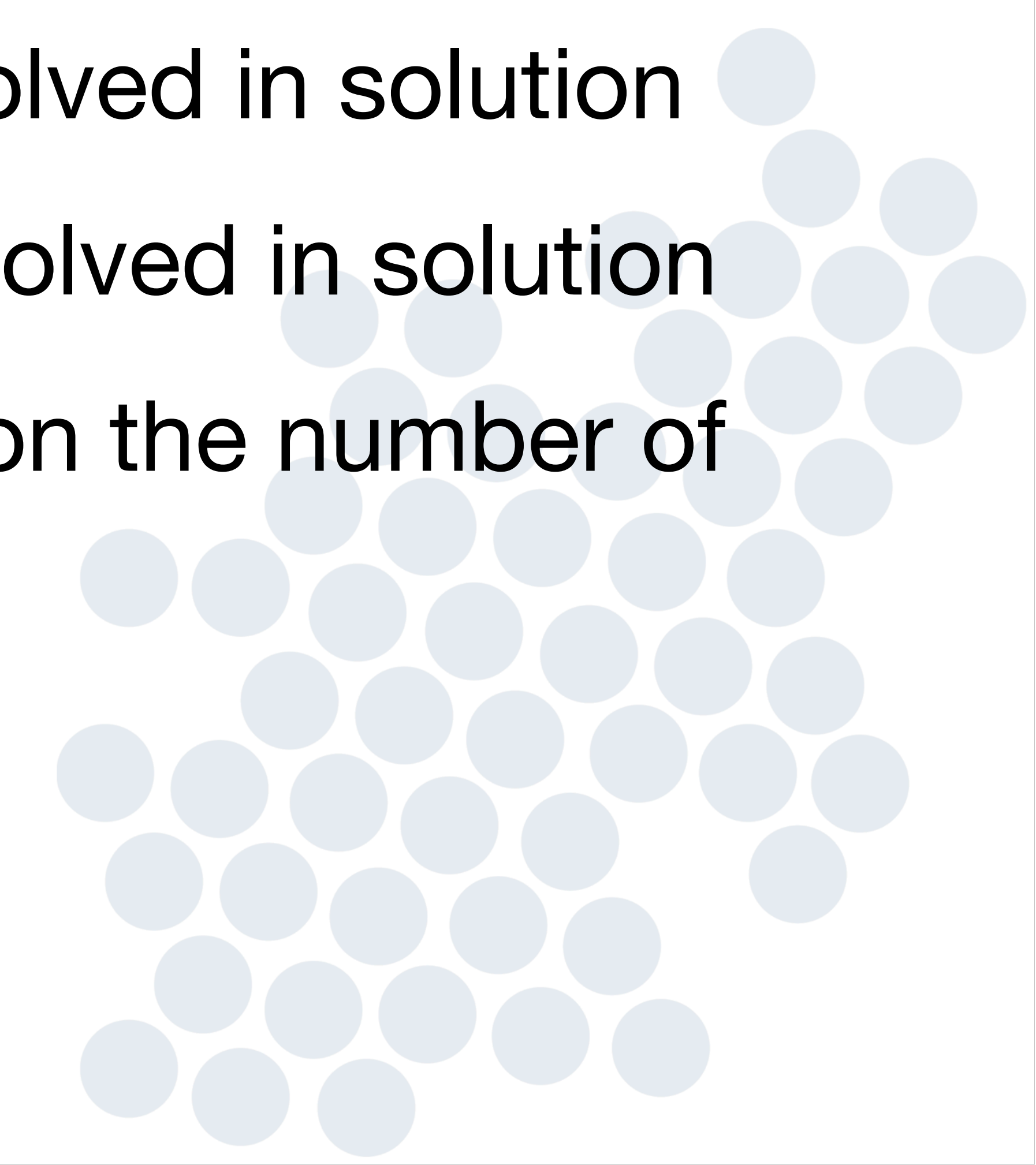
The Resin Bead in Action

Hydrogen ions are exchanged and exit producing improved water.





Definition of Ions

- Cations – Positively charged ions dissolved in solution
 - Anions – Negatively charged ions dissolved in solution
 - Law of Electroneutrality – In any solution the number of cations equals the number of anions
- 

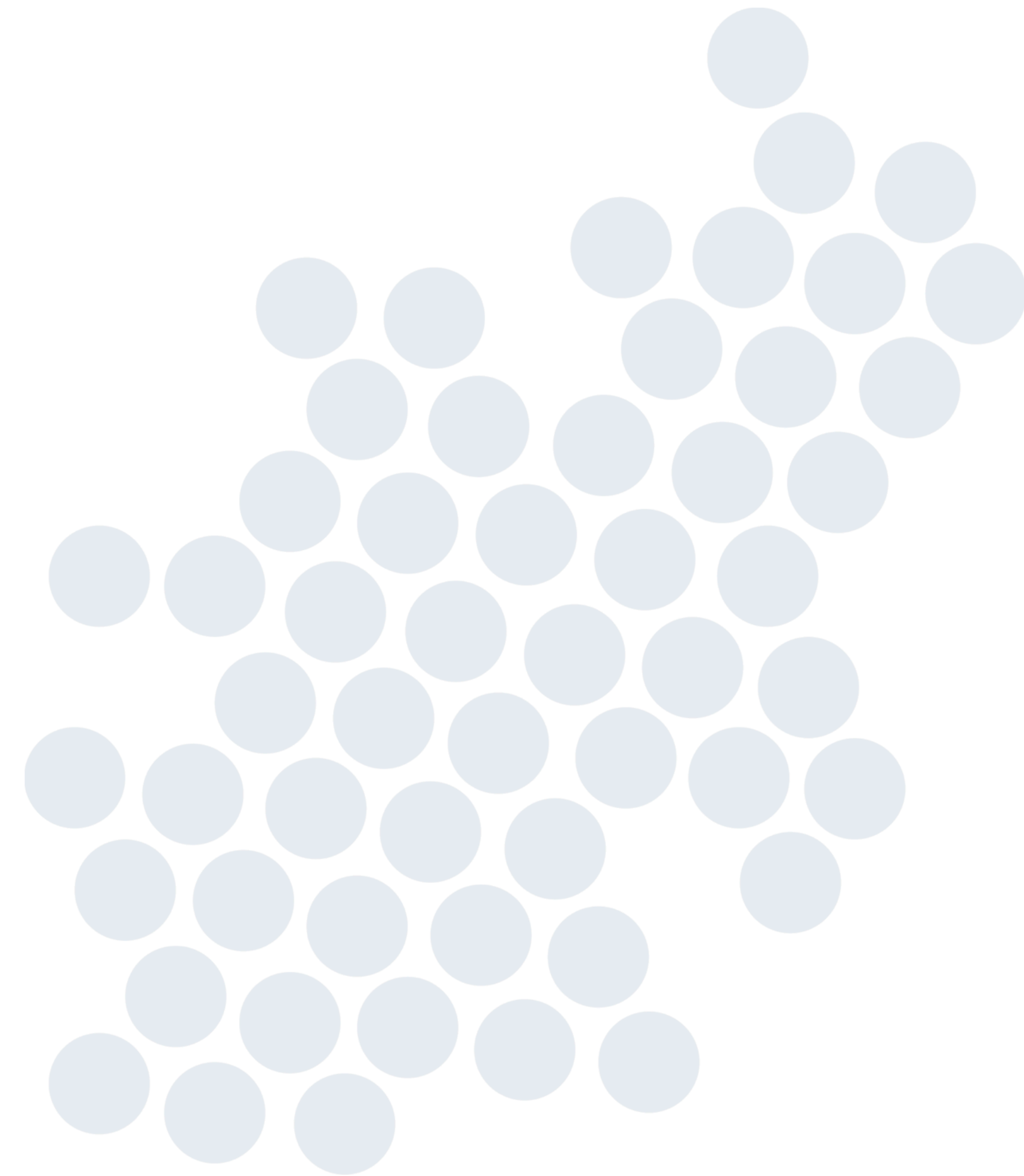
Selectivity

- The attraction, of one ion over another, to an ion exchange resin
- Function of ion charge, size and concentration
- For SACs and SBAs:
 - Bigger the ion, higher the charge, the more selective the ion becomes
 - I.e. $-3 > -2 > -1$ and $+3 > +2 > +1$



Basic Products

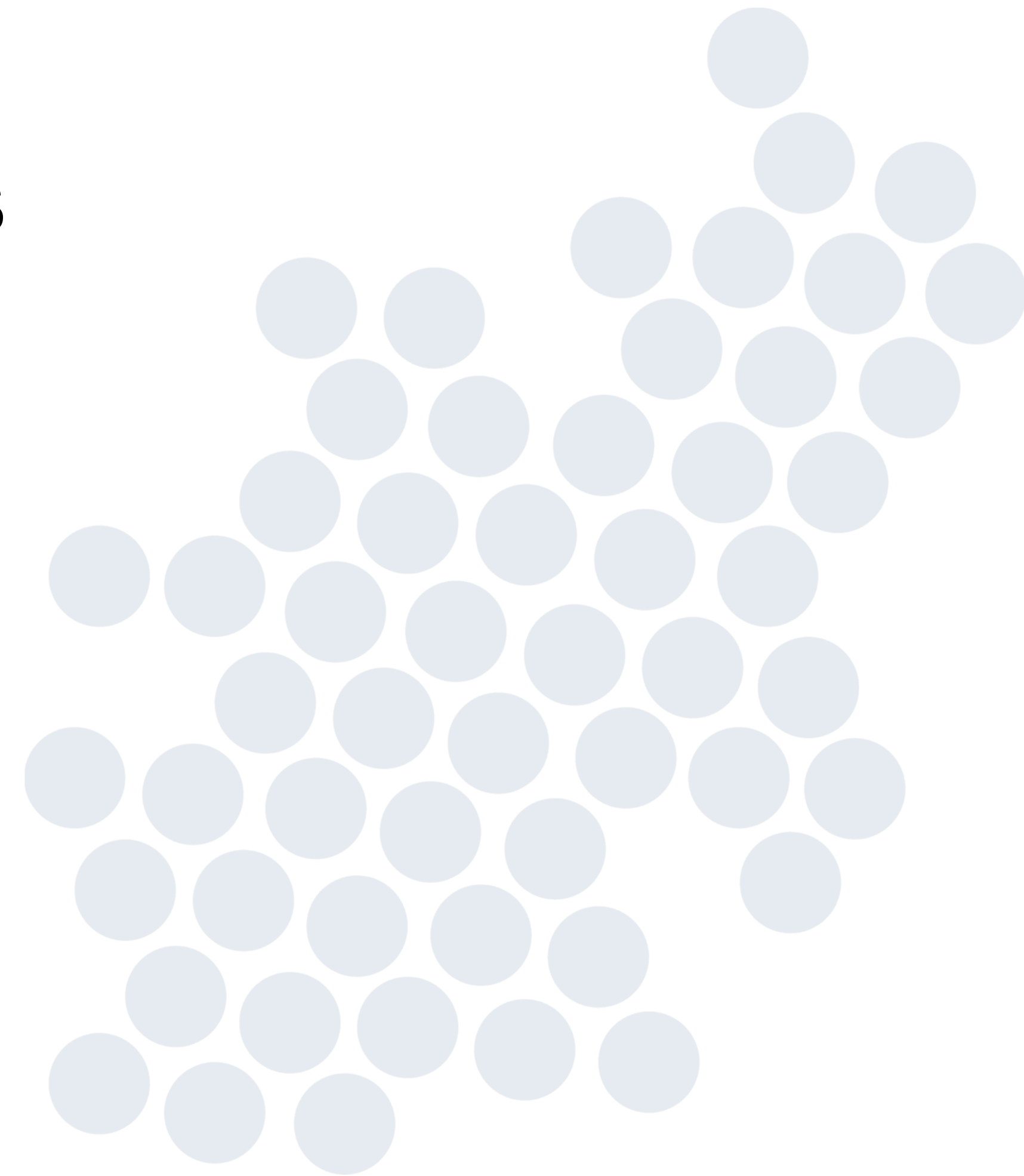
- Cation Resins (CGS)
- Anion Resins (SBG1P)
- Mixed Bed Resins
- Selective Resins & Zeolites (SIR-300)



Cation Resins



- Used to remove cations from water
 - Hardness, Heavy Metals or all cations
- Strong Acid Cation (CGS)
 - Typically use Na^+ or H^+ forms
- Weak Acid Cation
 - Typically use Na^+ or H^+ forms



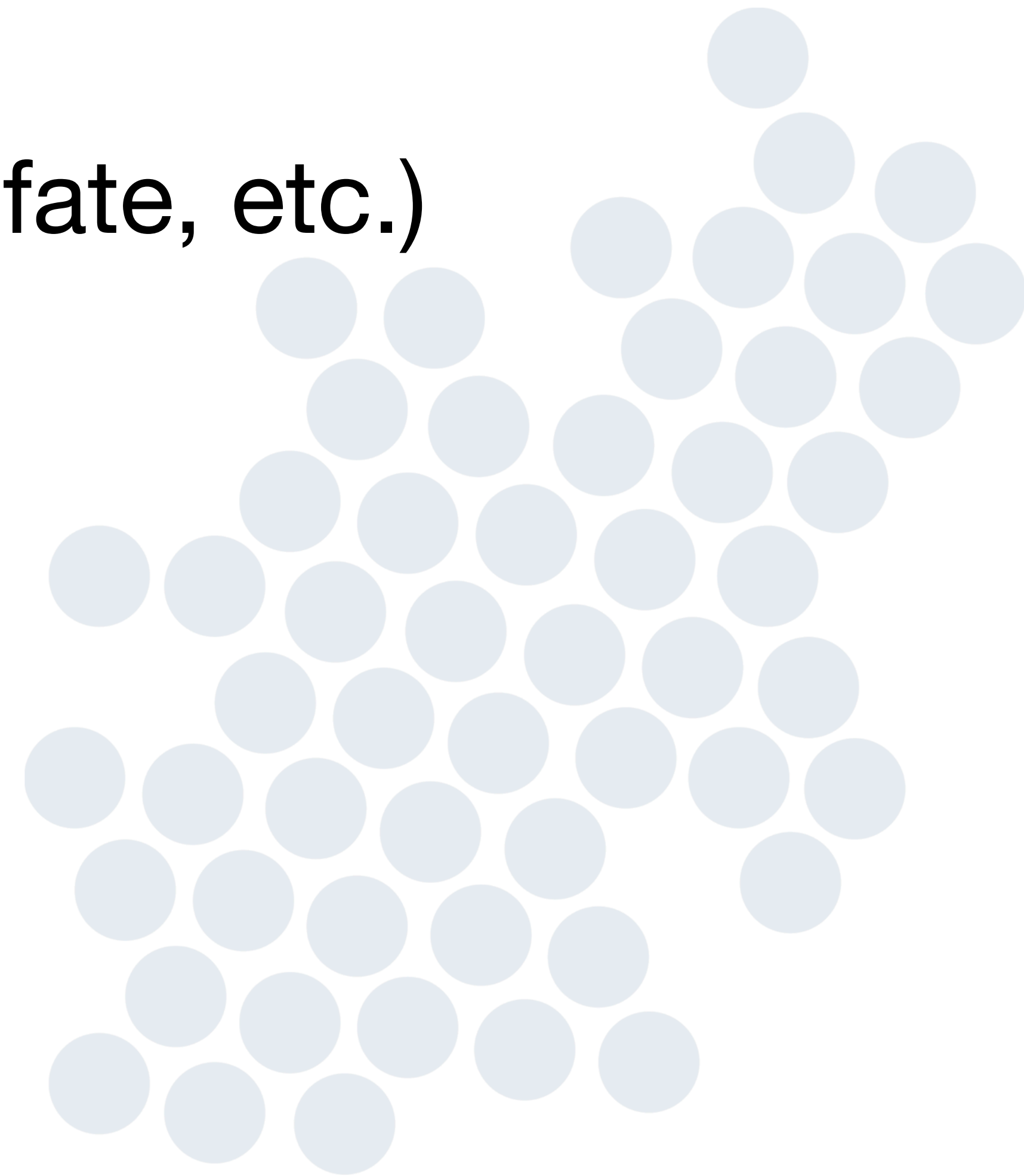
Common Cations

Iron	Fe²⁺
Calcium	Ca²⁺
Magnesium	Mg²⁺
Sodium	Na⁺
Potassium	K⁺
Hydrogen	H⁺

Anion Resins



- Used to remove anions from water
 - Complexes, oxy anions (Cromate, Sulfate, etc.)
- Strong Base Anion (SBG1P)
 - Typically use Cl^- or OH^- forms
- Weak Base Anion
 - Typically use Cl^- or free base forms

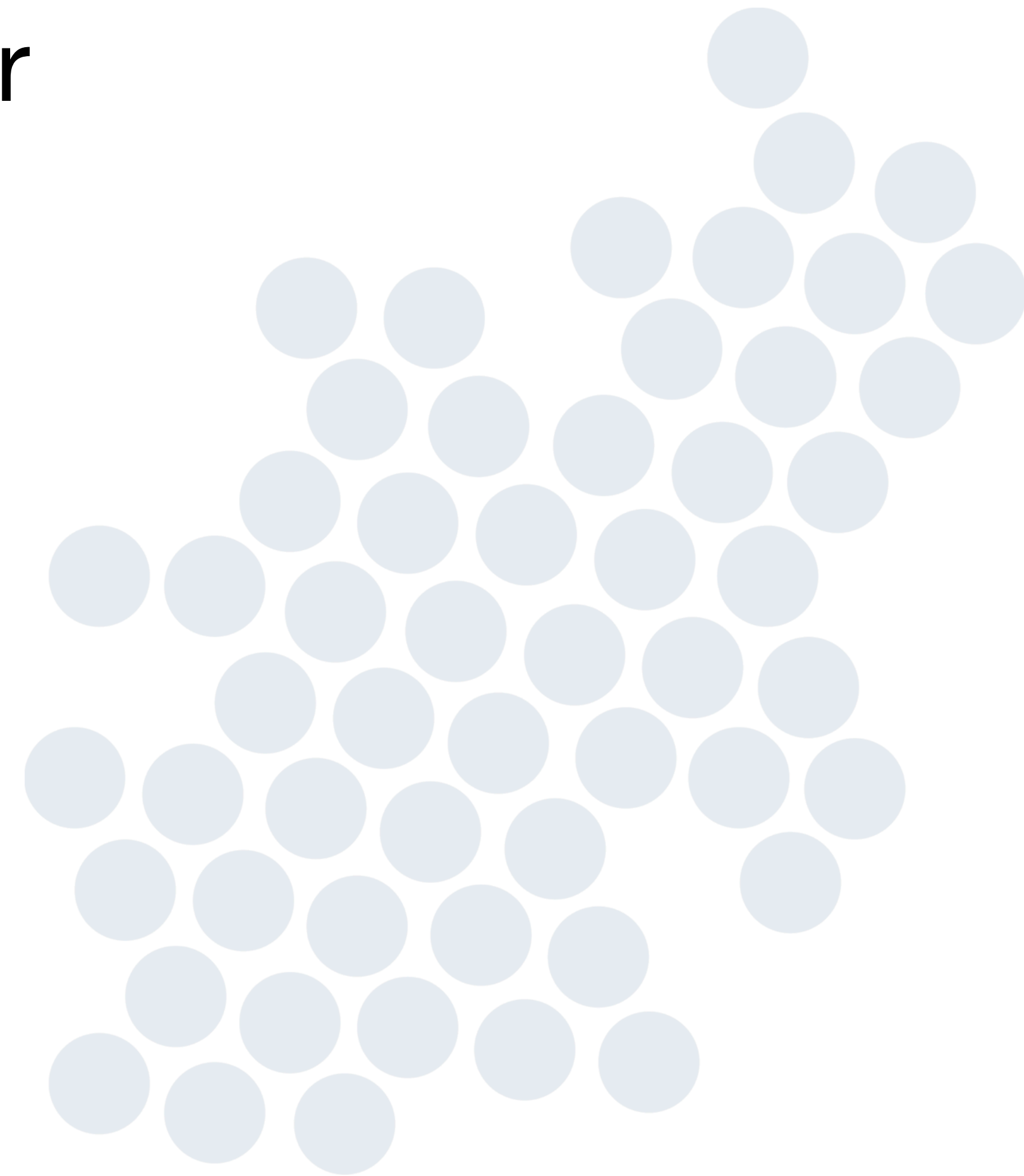


Common Anions

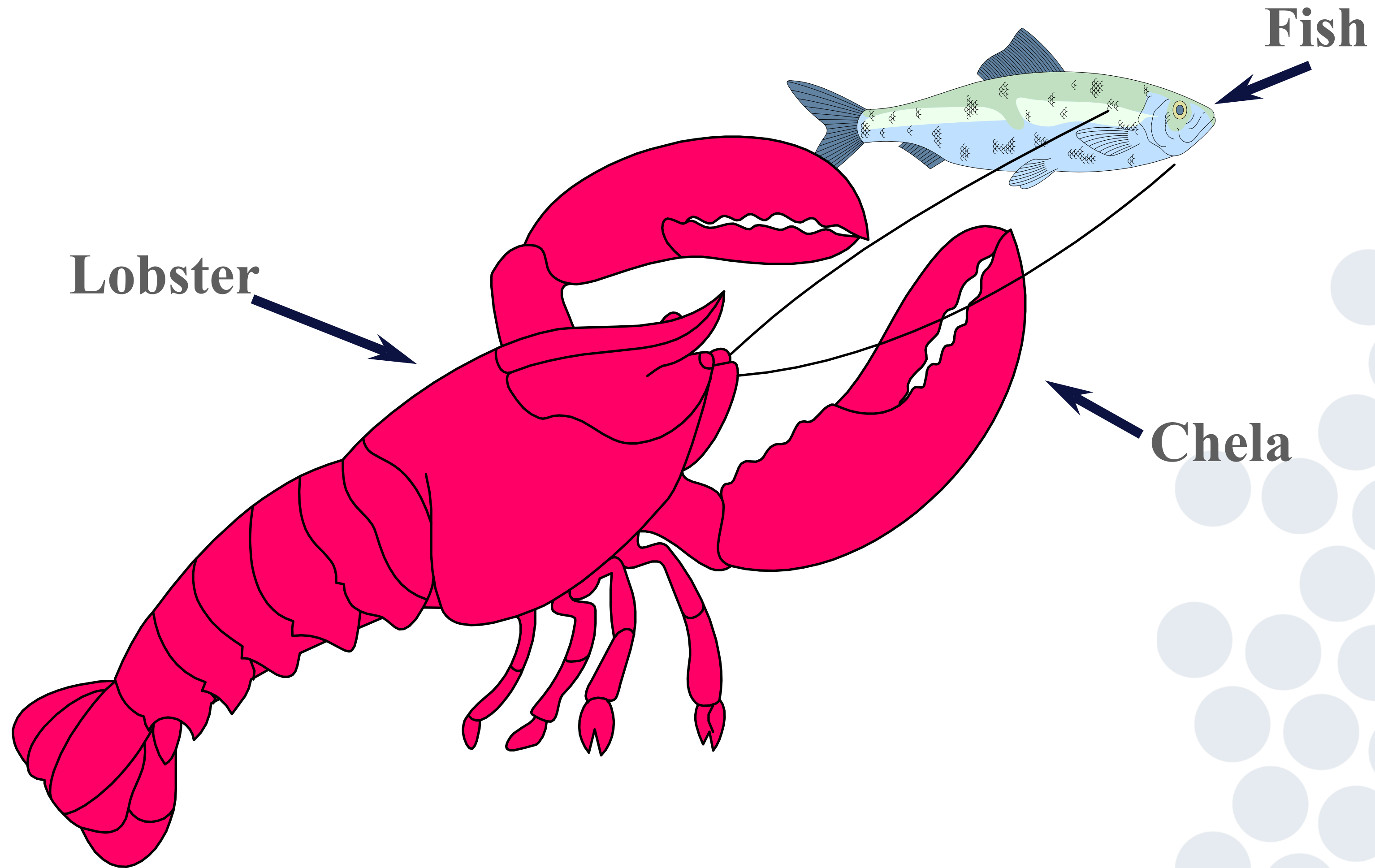
Phosphate	PO_4^{-3}
Sulfate	SO_4^{-2}
Nitrate	NO_3^-
Chloride	Cl^-
Bicarbonate	HCO_3^-
Hydroxide	OH^-

Selective Resins & Media

- Used to remove various ions from water
 - Heavy metals most common
- Chelating Resins
 - Typically use Na^+ or H^+ forms
 - Many types
- Ignores hardness and TDS
 - “pluck” metals out of water



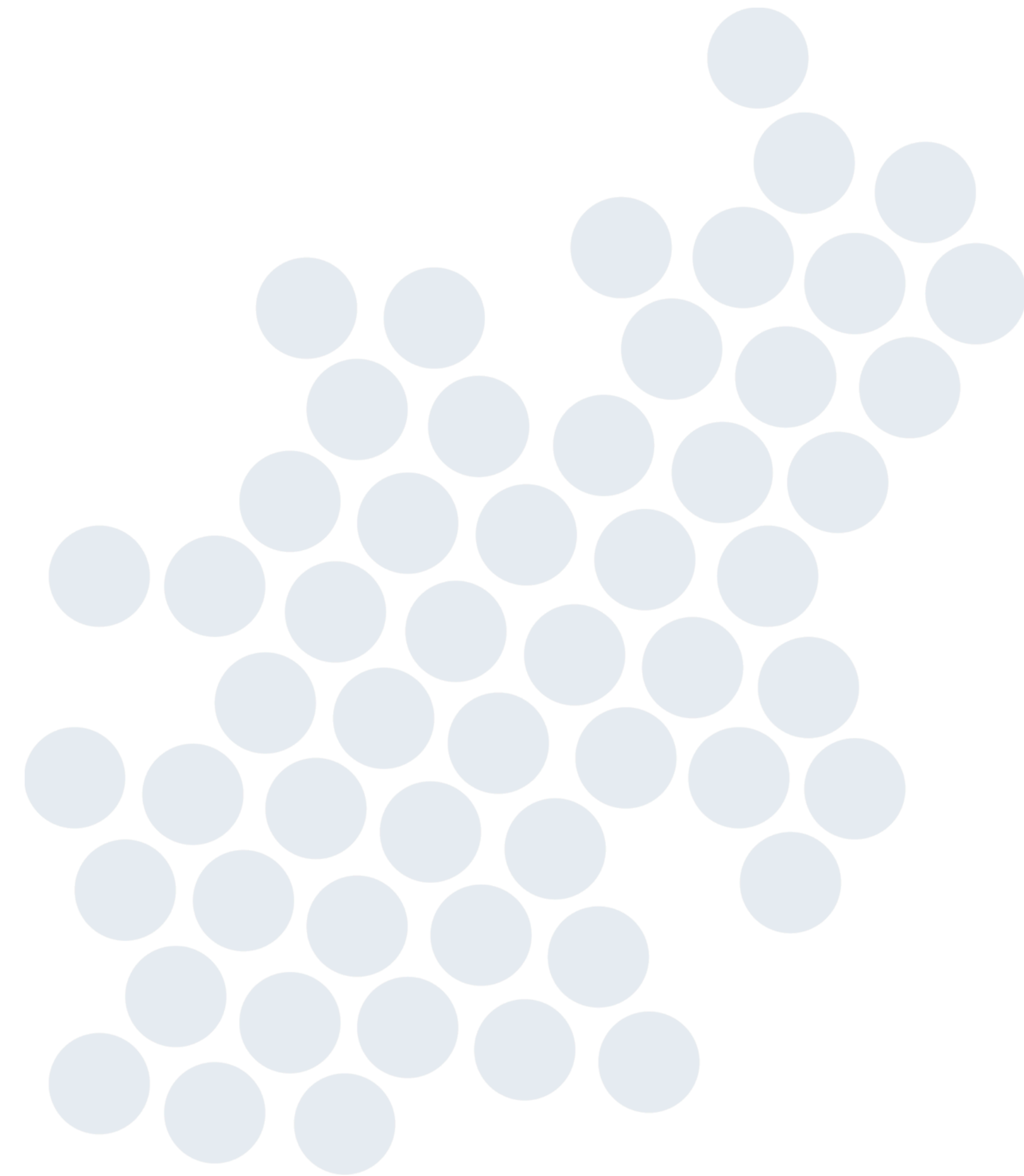
Chelating Lobster (SIR-300)





Resin Selection

- Feedwater analysis
- Desired effluent quality
- Operating conditions
- Economics
- Type of equipment
- Regeneration chemicals if available

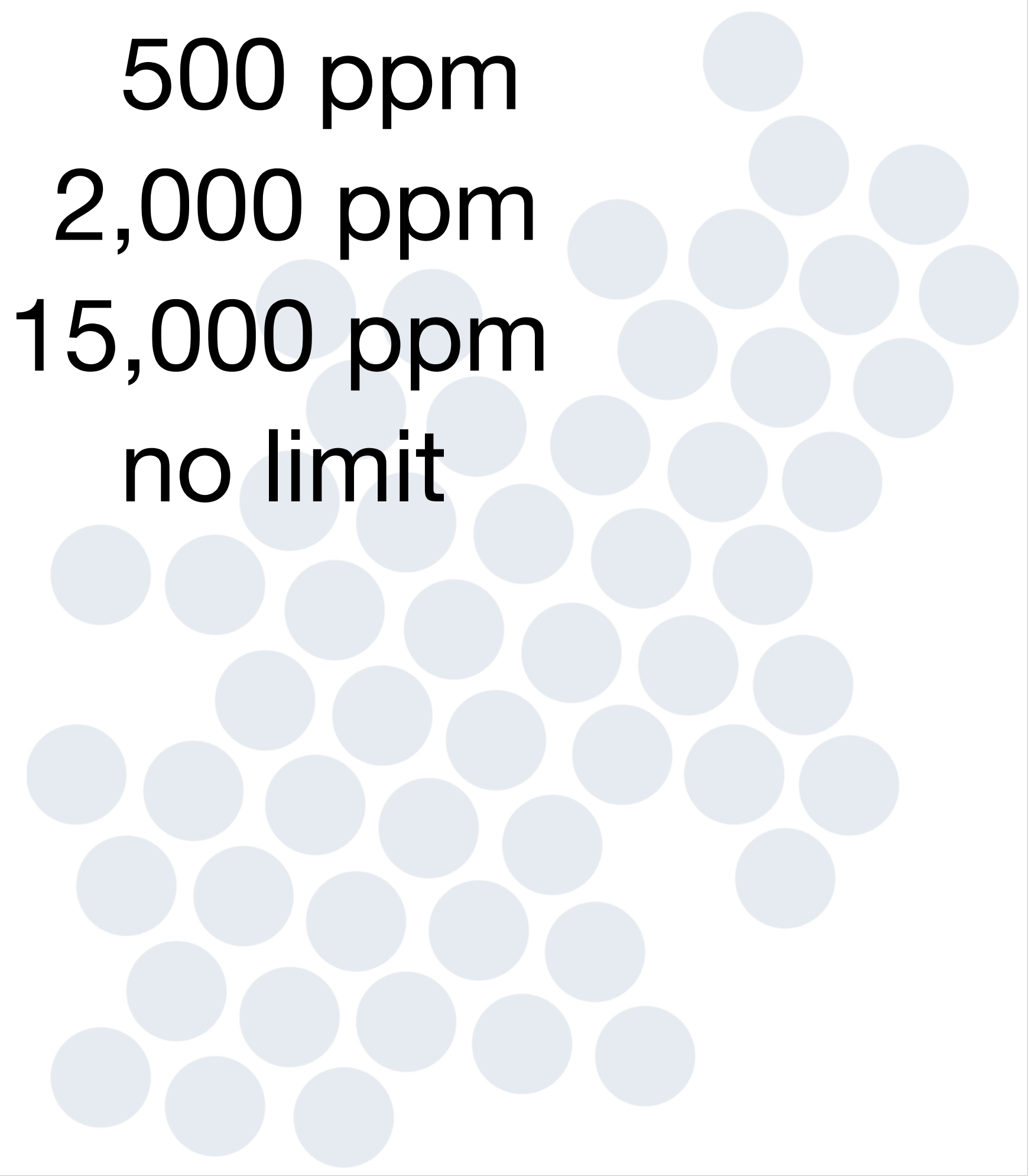


What do we need to Know?

- Viability of ion exchange
 - TDS (or conductivity)
 - pH
 - Basic inorganic analysis of ions (Ca, Mg, Na, Cl, SO₄)
 - Presence or absence of oxidants (air?)
 - presence or absence of complexing agents
 - TOC
 - Suspended Solids (TSS)



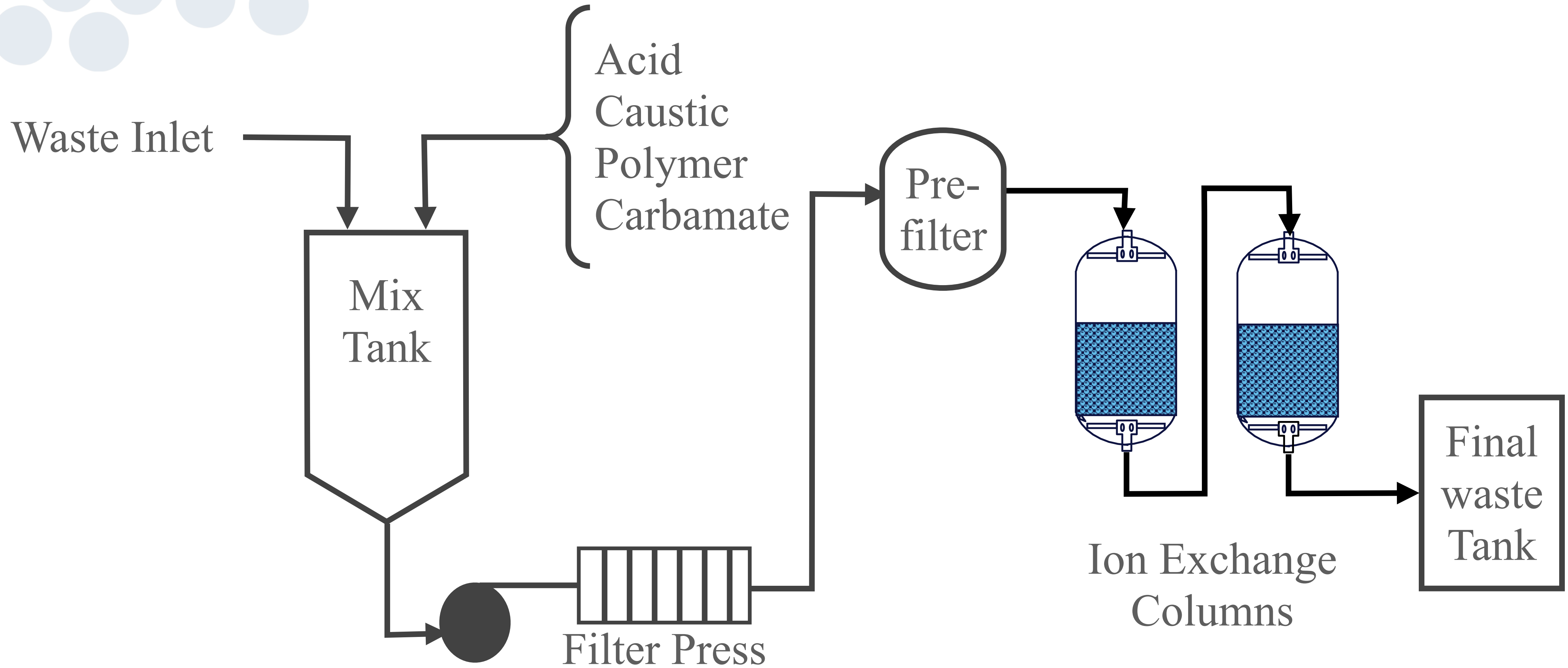
TDS Limits of various Resins Used for Metals Removal

- Strong Cation Resin (Hydrogen form) 500 ppm
 - Strong Cation Resin (Sodium form) 2,000 ppm
 - Weak Cation Resin (Sodium form) 15,000 ppm
 - Chelating Cation Resin (Sodium form) no limit
- 

Application Information

- CGS & SBG1P will be your main products
 - Apply at 2-5 GPM/Cuft
 - Need at least 20 bed volumes (150 gal/Cuft) before sampling (mainly due to VOC throw)
- SIR-300 (less often used, brackish waters)
 - Apply at 1-2 GPM/Cuft
 - pH issues need to be addressed
- TSS must be controlled (<0.5 ppm ideal)

Bulk Waste Treatment Schematic



The Capacity Question...

- More information the better
- Estimations are as good as the data provided
- Always given in good faith, most times it's a best guess
- Cover yourself!!

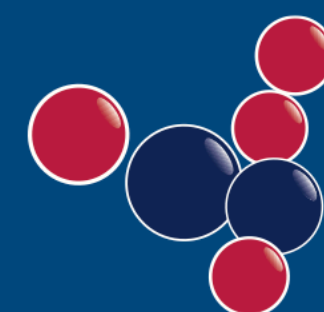
THANK YOU

Bill Koebel

Eastern Regional Sales Mgr

p. 412-716-7921

e. wkoebel@resintech.com



RESINTECH[®] INC.

INNOVATIONS IN ION EXCHANGE