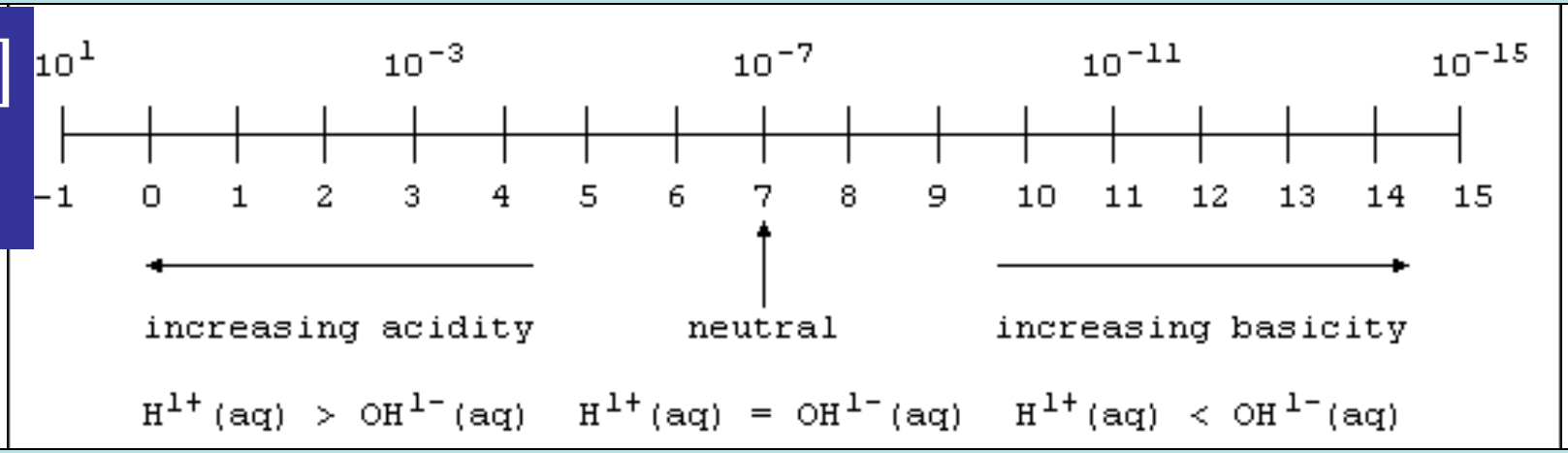
Measuring pH

$[H^+]$

pH



$$[H^+] \times [OH^-] = \text{cost} = 10^{-14}$$

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$[H^+]$ in biological fluids is described by
very small numbers (10^{-x})
whose even smaller variations produce big effects !

Then…**pH**
i.e. colog (-log x = log 1/x) to base 10
of $[H^+]$

$[H^+] = 10^{-7}$ M ?
the log $1/10^{-7} = \log 10^7 = 7$
pH = 7 *(neutral pH!)*

$[H^+] = 10^{-4}$ M ?

the log (*to base 10*) of $1/10^{-4} = \log 10^4 = 4$

pH = 4

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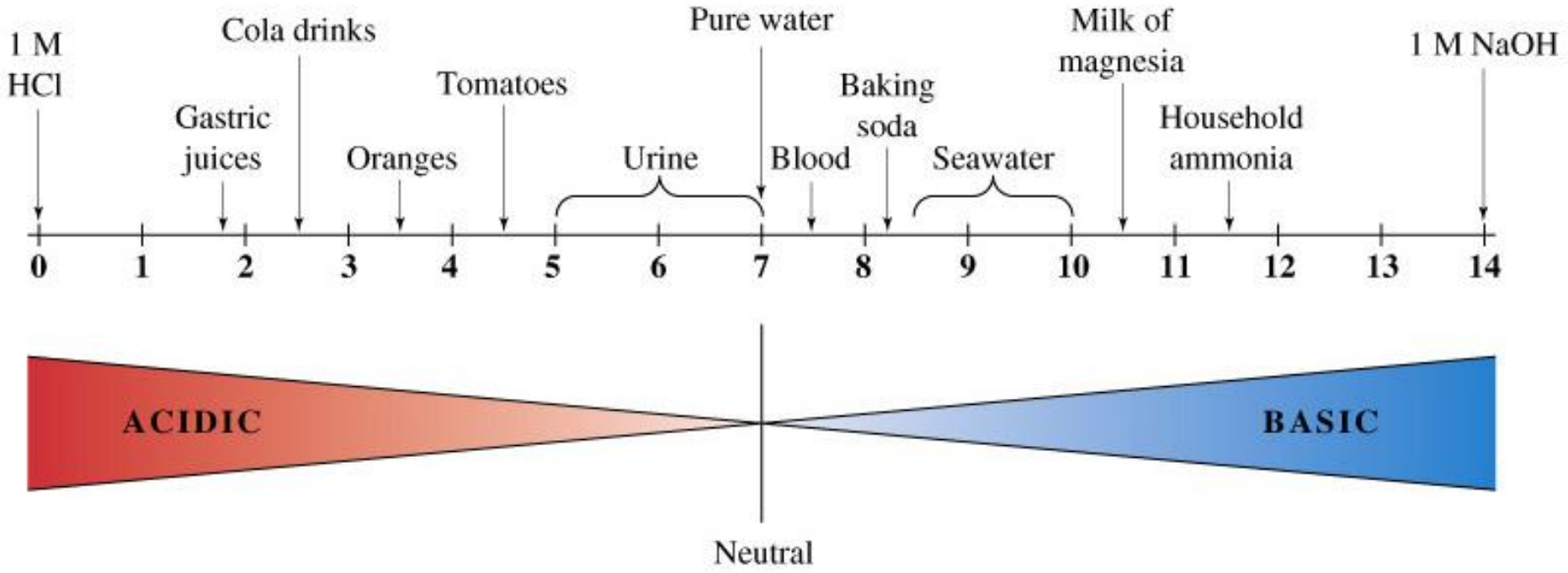
Biological fluids pH



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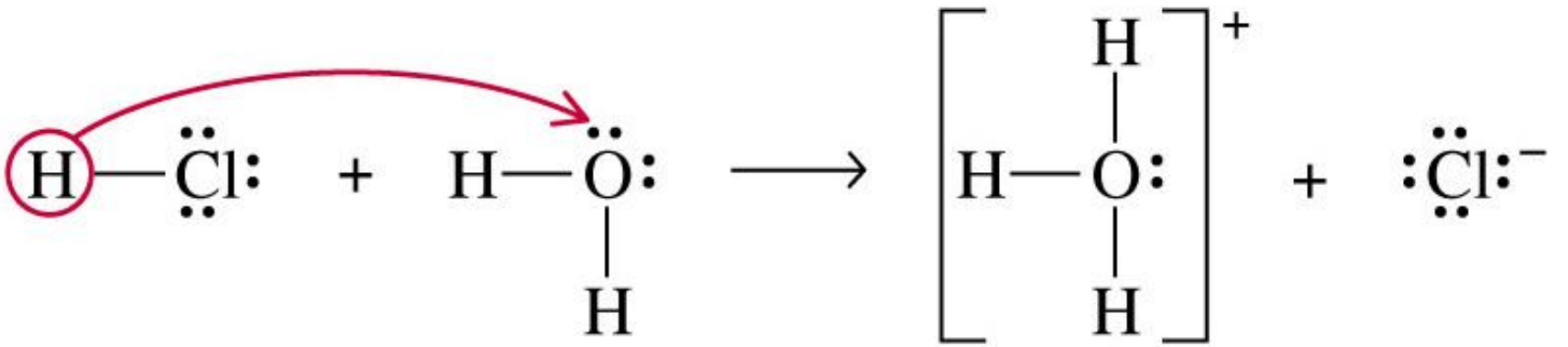

Acid Base

0.1 M 55.5 M 0.1 M 0.1 M

$$pH = \log 1/0.1 = 1.0$$

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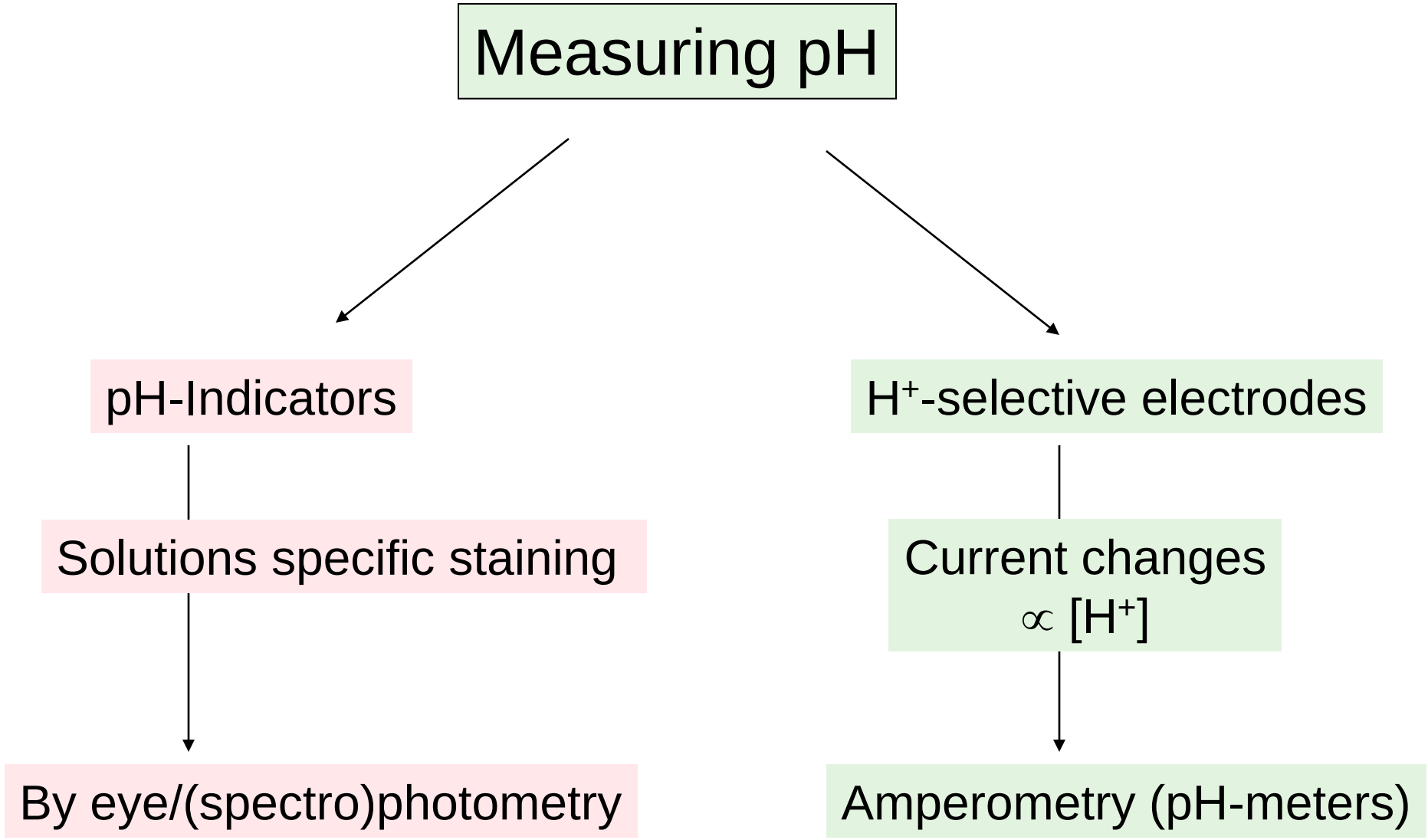

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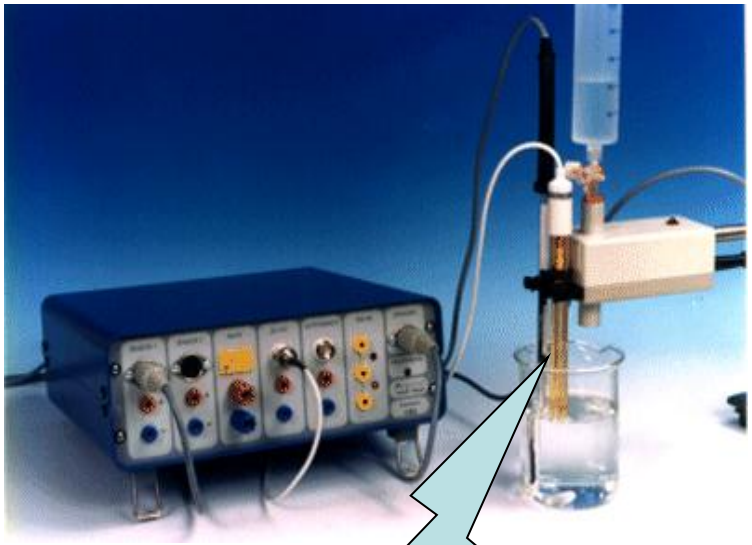
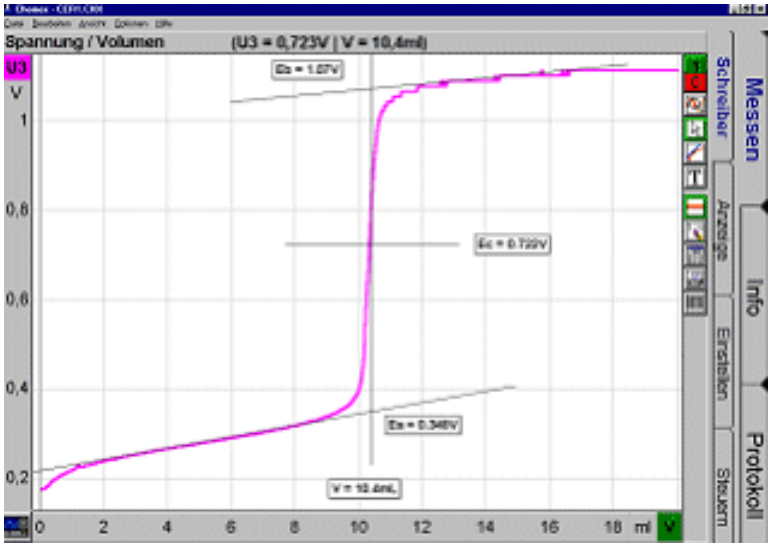
H^+-amperometry



Elettrode pH-meter



Acid-base titration

Ex.

$$InH \overset{H_2O}{\rightleftharpoons} In^- + H^+$$

yellow red

$$K_{In} = \frac{[In^-]\ [H^+]}{[InH]}$$

Solving for H^+

$$[H^+] = K_{In} \frac{[InH]}{[In^-]} \rightarrow \log 1/[H^+] = pH$$

$$pH = pK_{In} + \log \frac{[In^-]\ (red)}{[InH]\ (yellow)}$$

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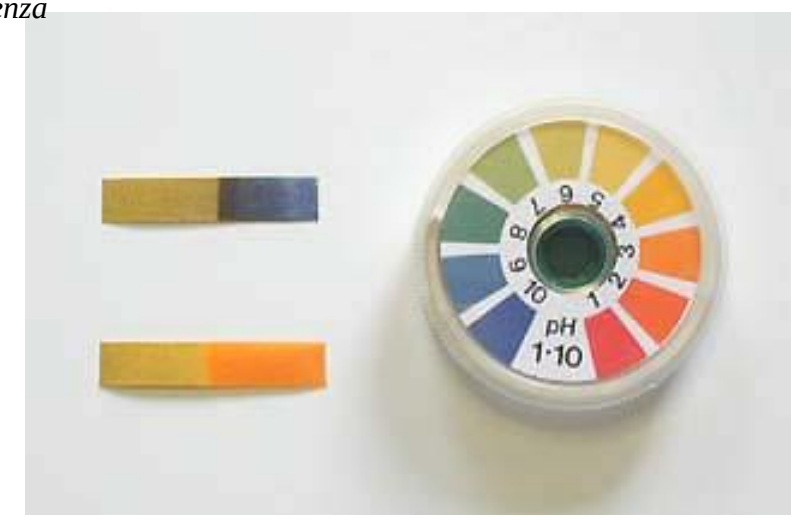
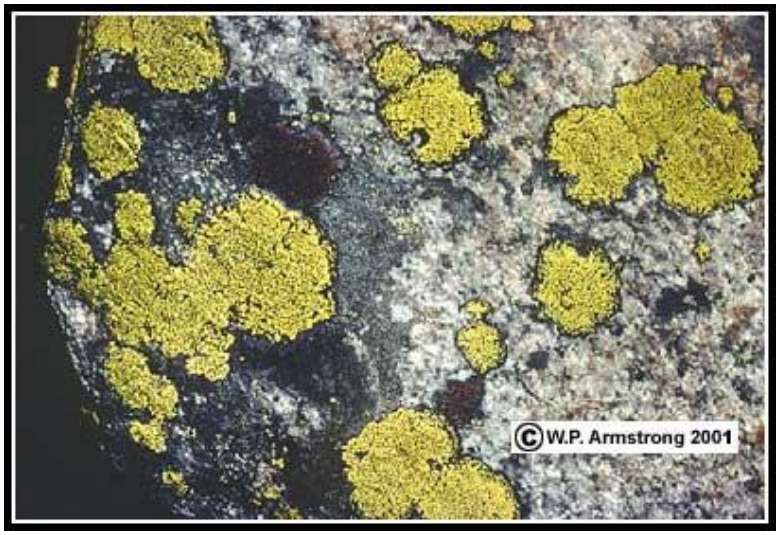
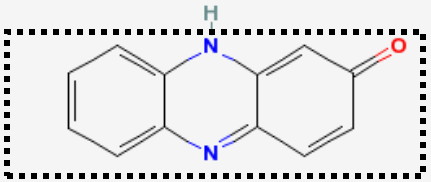


Rocella tinctoria tornasole



H

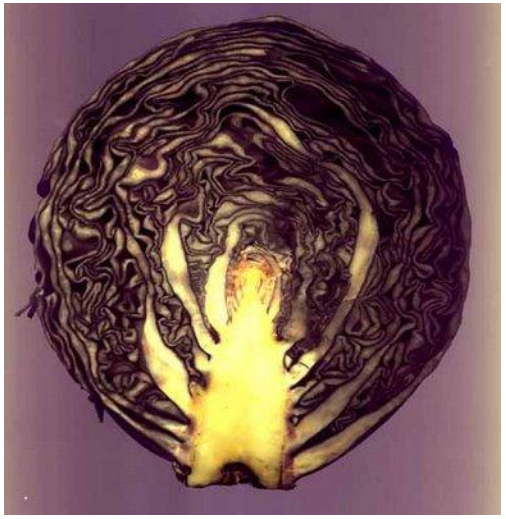
A = In



2-hydroxyphenazine

$$\underset{\text{dye 1}}{AH} + H_2O \rightleftharpoons \underset{\text{dye 2}}{A^-} + H^+$$

Boiling the “red cabbage” !!



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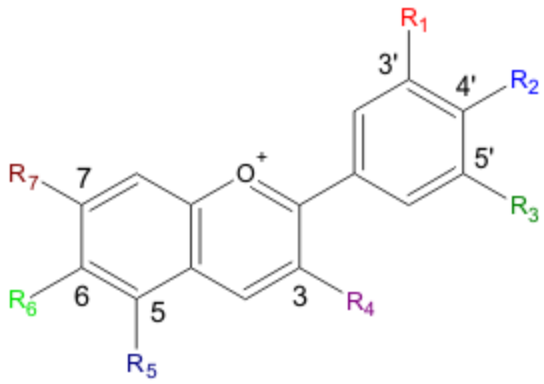

anthocyanin

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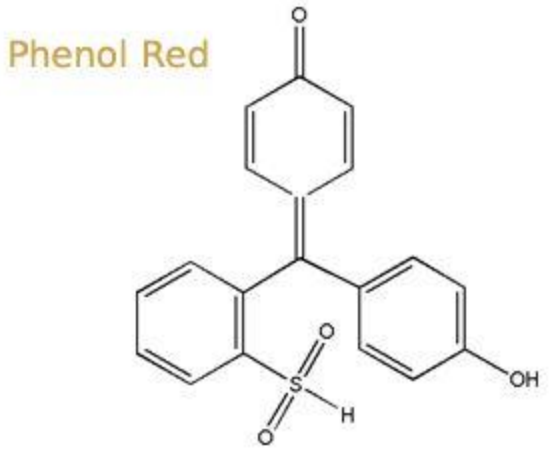
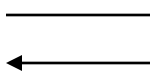
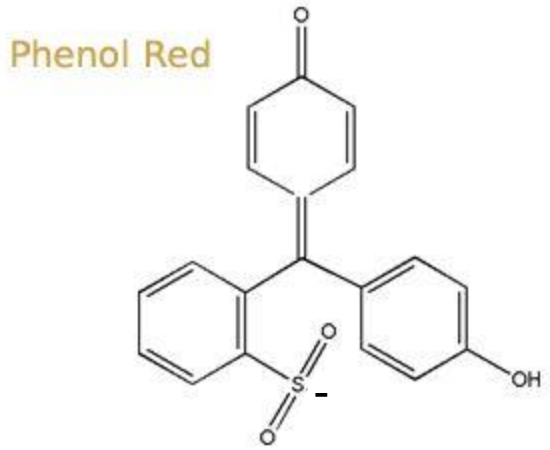
Phenol red







+ H^+

InH

protonated

yellow

In^-

deprotonated

red

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Es.

$$InH \xrightleftharpoons{H_2O} In^- + H^+$$

yellow red

$$K_{In} = \frac{[In^-]\ [H^+]}{[InH]}$$

Solving for H^+

$$[H^+] = K_{In} \frac{[InH]}{[In^-]} \rightarrow \log 1/[H^+] = pH$$

$$pH = pK_{In} + \log \frac{[In^-]\ (red)}{[InH]\ (yellow)}$$

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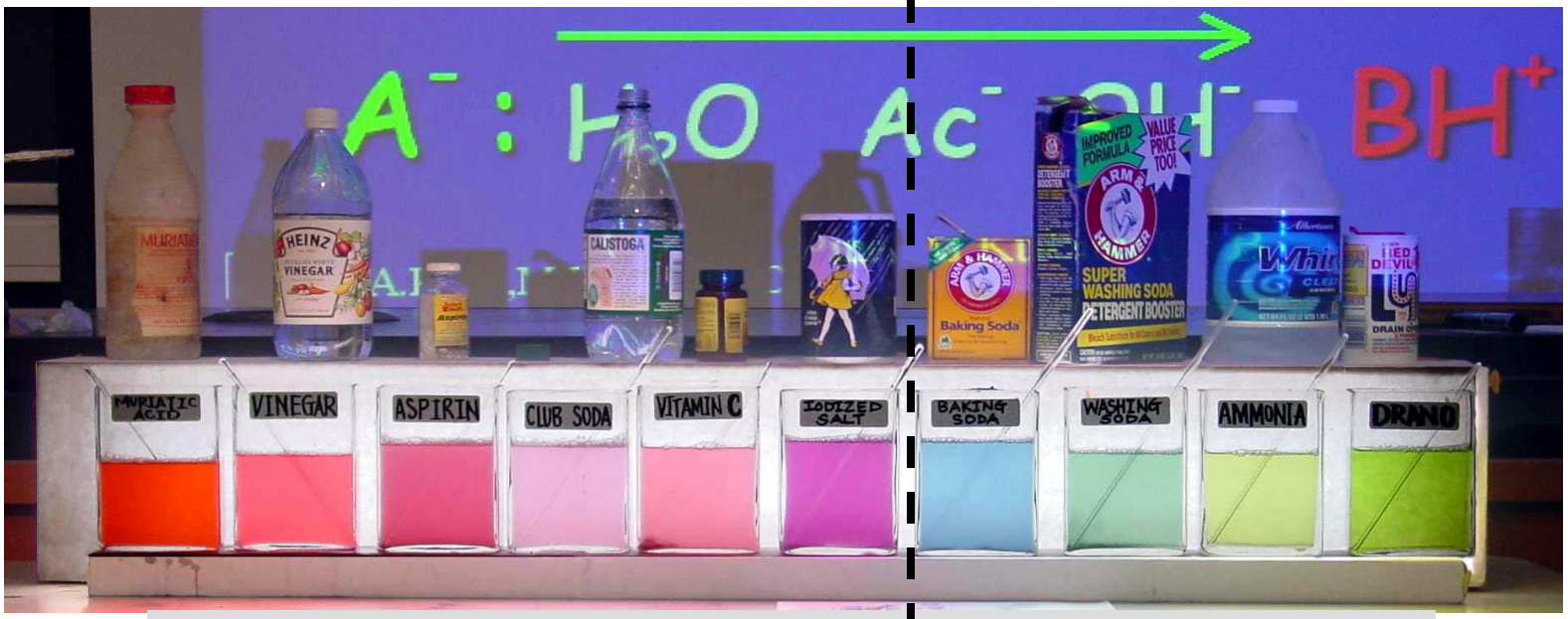
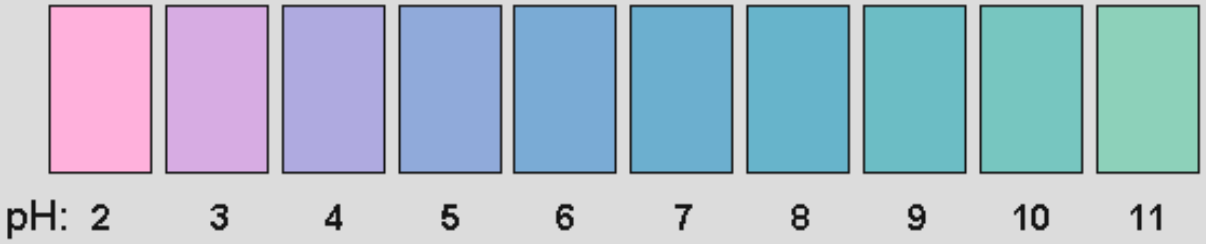
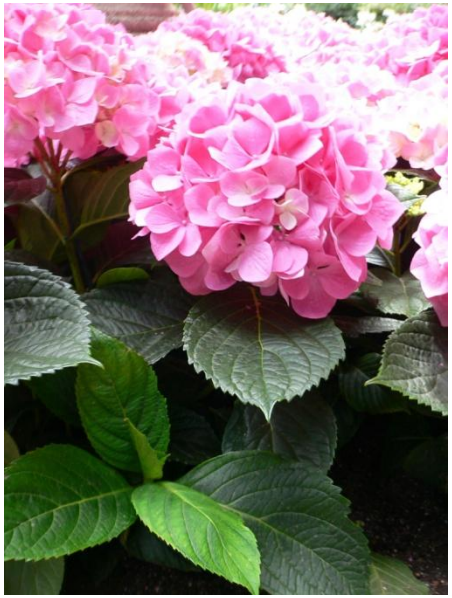
pH = 1.0 ÷ 4.0

pH = 4.0 ÷ 11.0



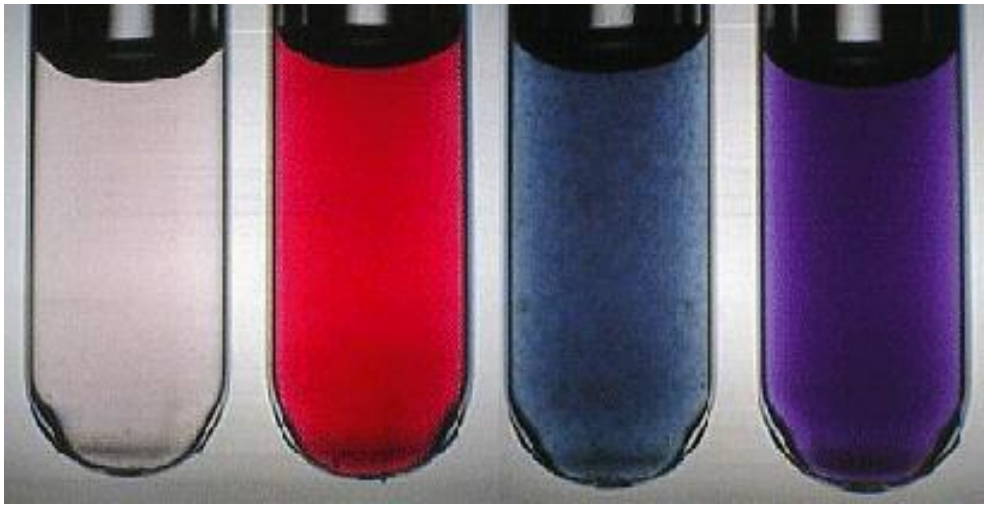


pH-dependent staining of antocyanine

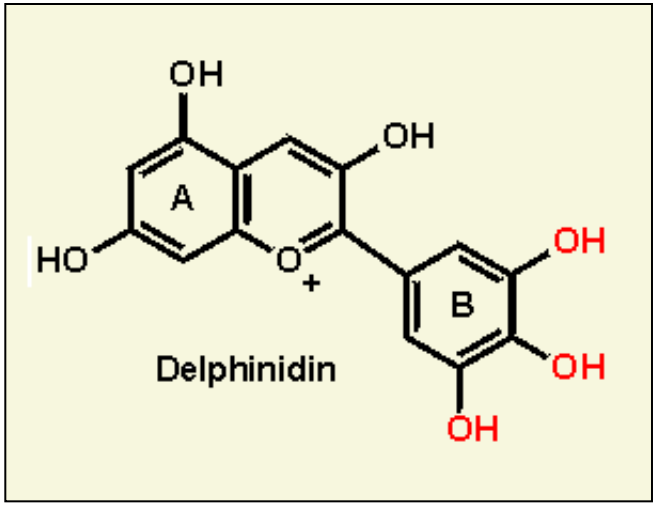


Alkaline soil

Acidic soil



extract



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pH Indicators provide

- One quantitative info → at the color change (transition) point, when pH = PK_{In}
- Two qualitatives info → pH > pK_{In} pH < pK_{In}

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Common pH indicators

Indicator	pH Range in which Colour Change Occurs	Colour Change as pH Increases
Crystal violet	0.0 - 1.6	yellow to blue
Thymol blue	1.2 - 2.8	red to yellow
Orange IV	1.4 - 2.8	red to yellow
Methyl orange	3.2 - 4.4	red to yellow
Bromcresol green	3.8 - 5.4	yellow to blue
Methyl red	4.8 - 6.2	red to yellow
Chlorophenol red	5.2 - 6.8	yellow to red
Bromthymol blue	6.0 - 7.6	yellow to blue
Phenol red	6.6 - 8.0	yellow to red
Neutral red	6.8 - 8.0	red to amber
Thymol blue	8.0 - 9.6	yellow to blue
Phenolphthalein	8.2 - 10.0	colourless to pink
Thymolphthalein	9.4 - 10.6	colourless to blue
Alizarin yellow	10.1 - 12.0	yellow to blue
Indigo carmine	11.4 - 13.0	blue to yellow

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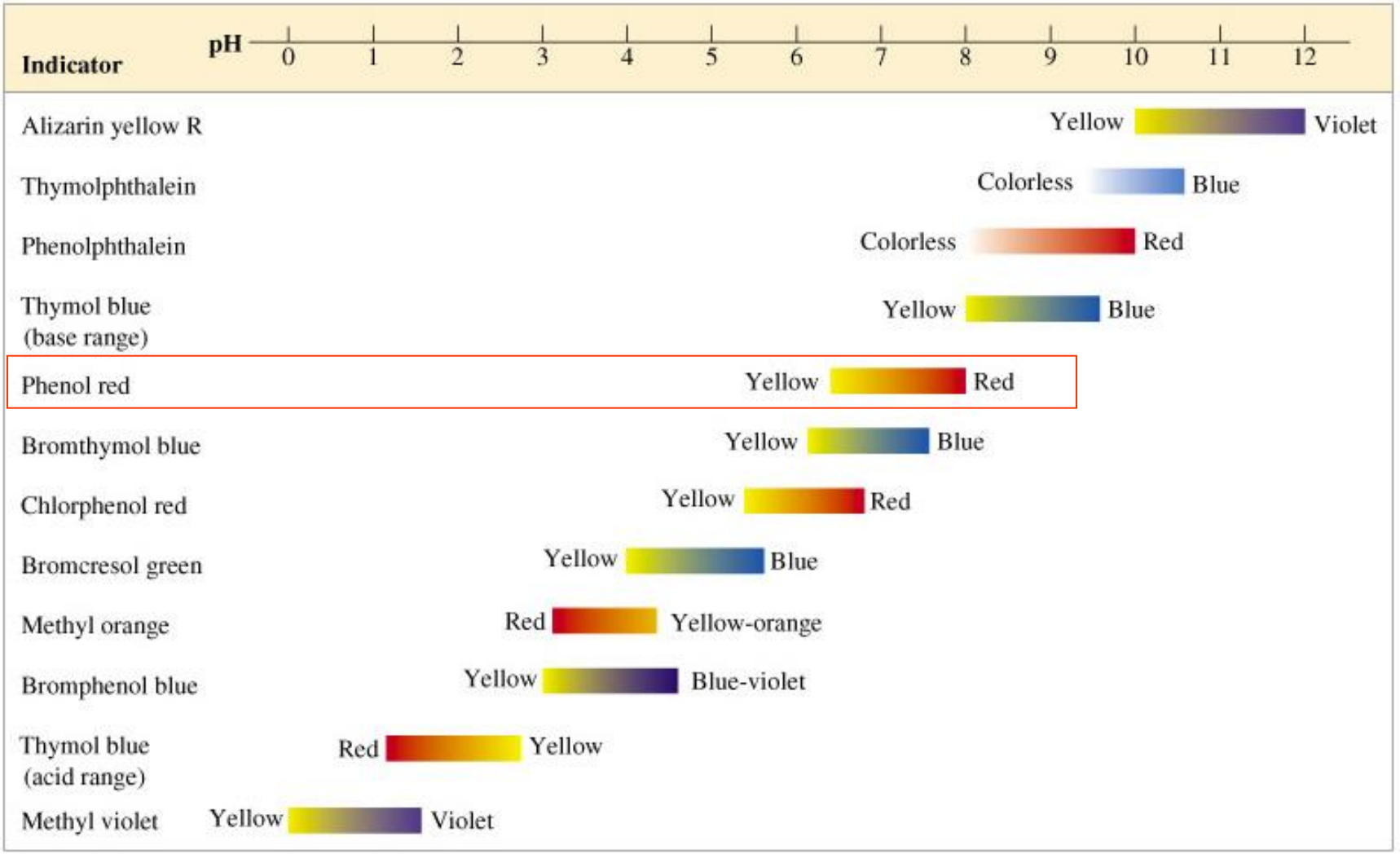
pH Indicators



Turning point → pH = pK_{In}