Roles of Soil Organic Matter

Function of humic substance

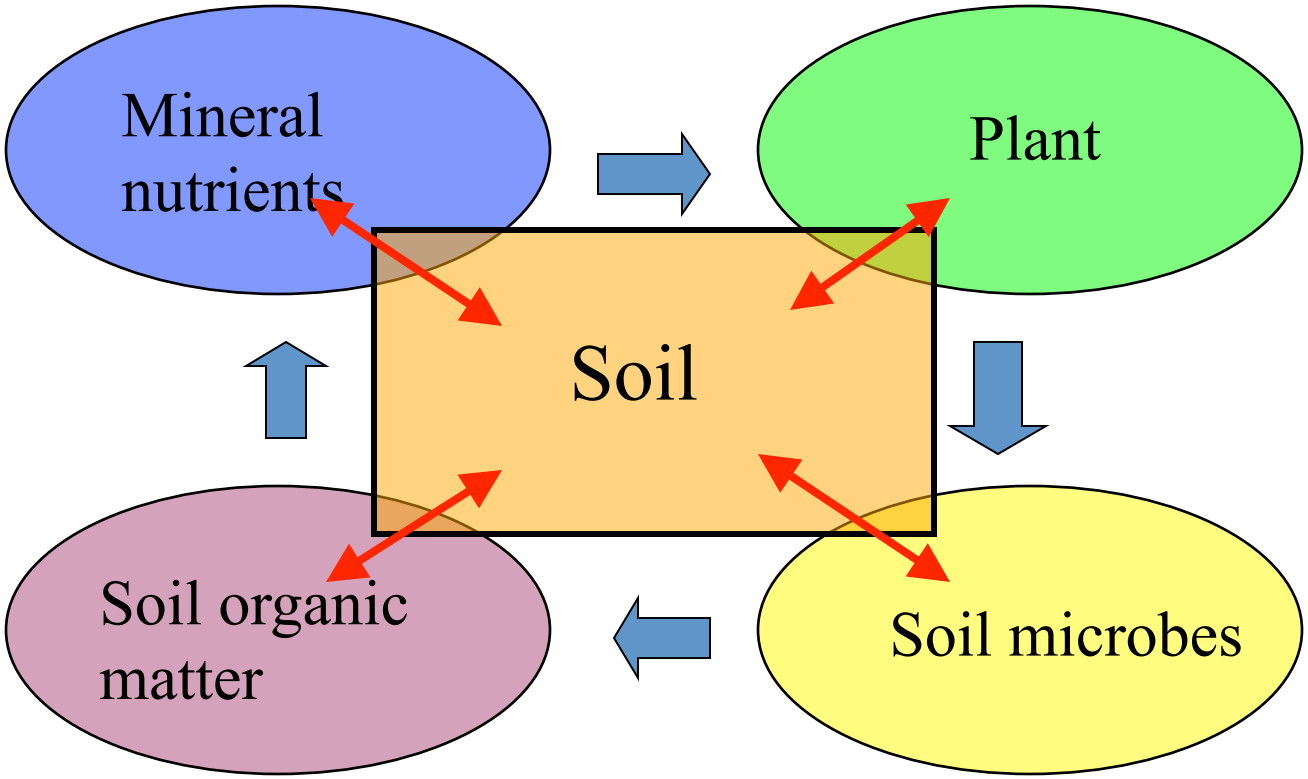
- Largest pool of carbon on the surface of earth
- Repress global warming
- Nutrition supply to plant and microbes
- Hold nutrients and water
- Improve soil physical properties
- Promote plant growth

Humic substance is not almighty, however.

- Humic substance can not support the growth of crops by itself.
- Optimum pH
- Favorable moisture condition
- Sufficient mineral nutrients
- No growth inhibiting substance

should be the background for the effect of humic substances

Role of soil organic matter



Role of Soil Organic Matter

Improvement in

a . Soil Physical properties

b . Chemical & Biological prpperties

c . Plant Growth Promotion Effects

Change in concept of plant nutrition

- J.Tull (early 18th century） Importance of plowing
- A. von Thaer (early 18th century）

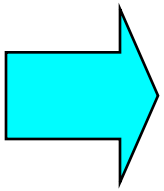
  Theory of humus nutrition
- Theodore de Saussure (early 19th century）

  Importance of mineral nutrition.

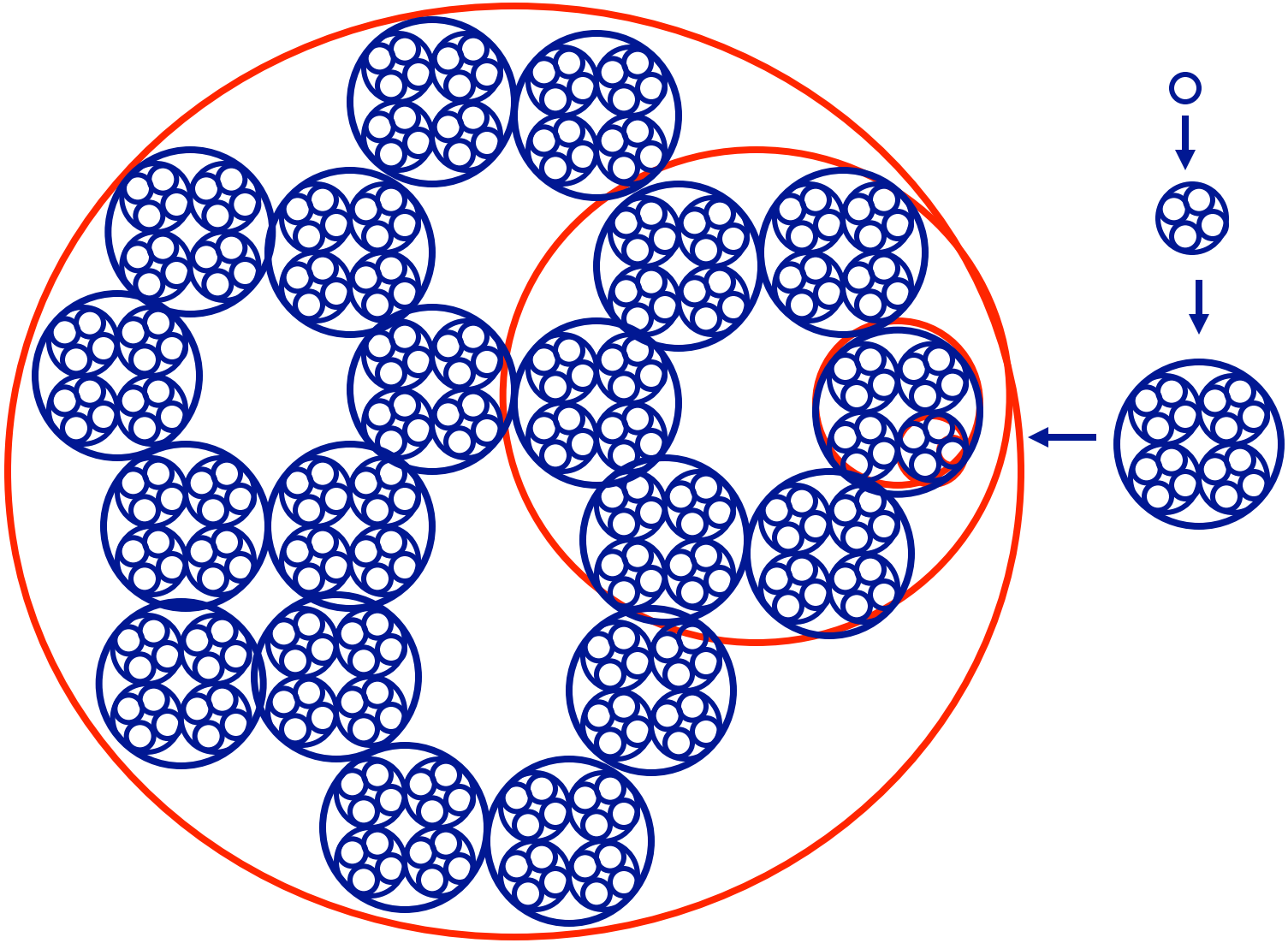
  Discovery of photosynthesis
- J.B. Boussingault (1834) Discovery of nitrogen fixation
- J. von Liebig (1840) Mineral nutrition theory

a． Improvement of Soil Physical properties by soil organic matter

Hyphae of fungi
Polysaccharide
Humic substance

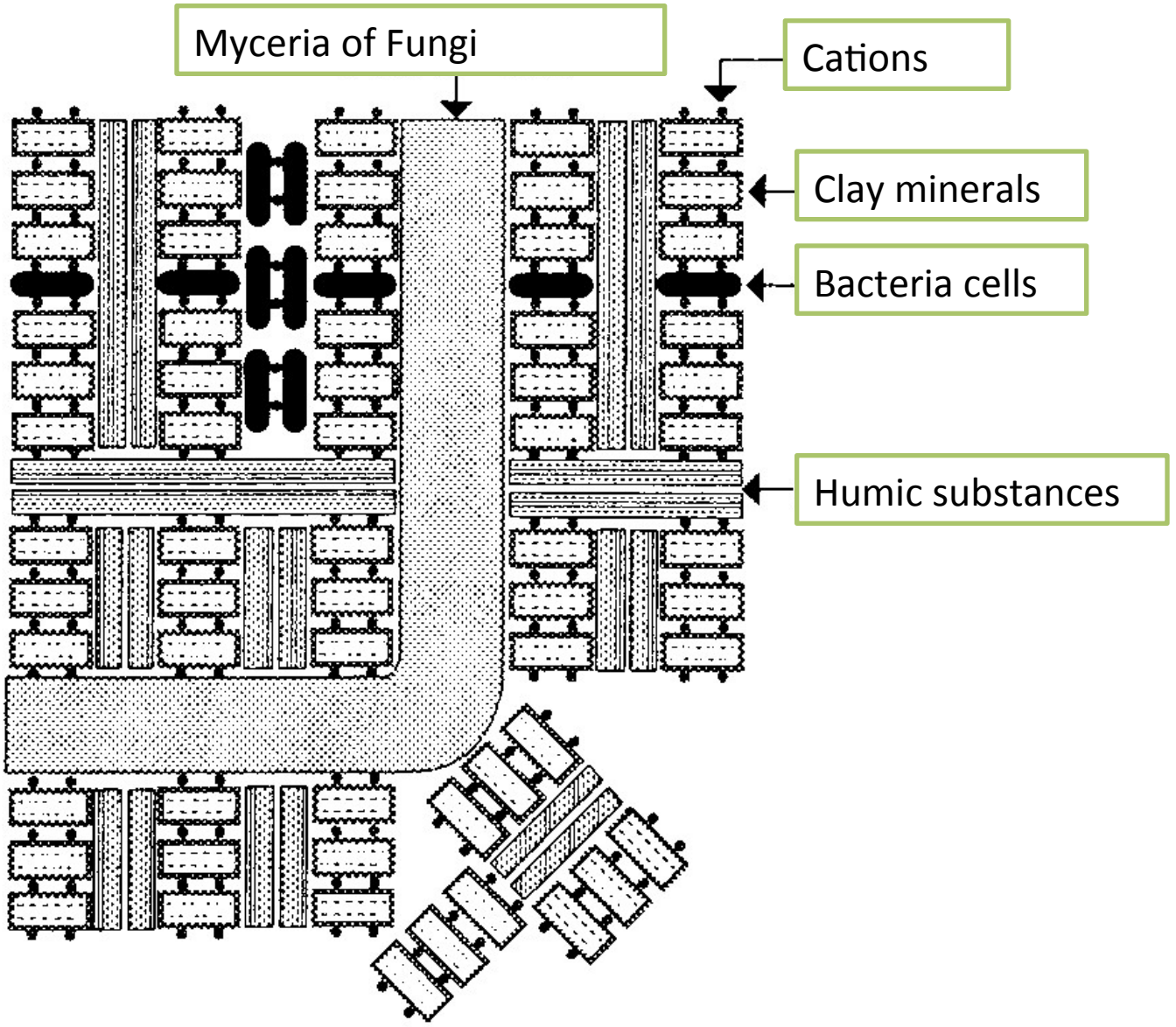


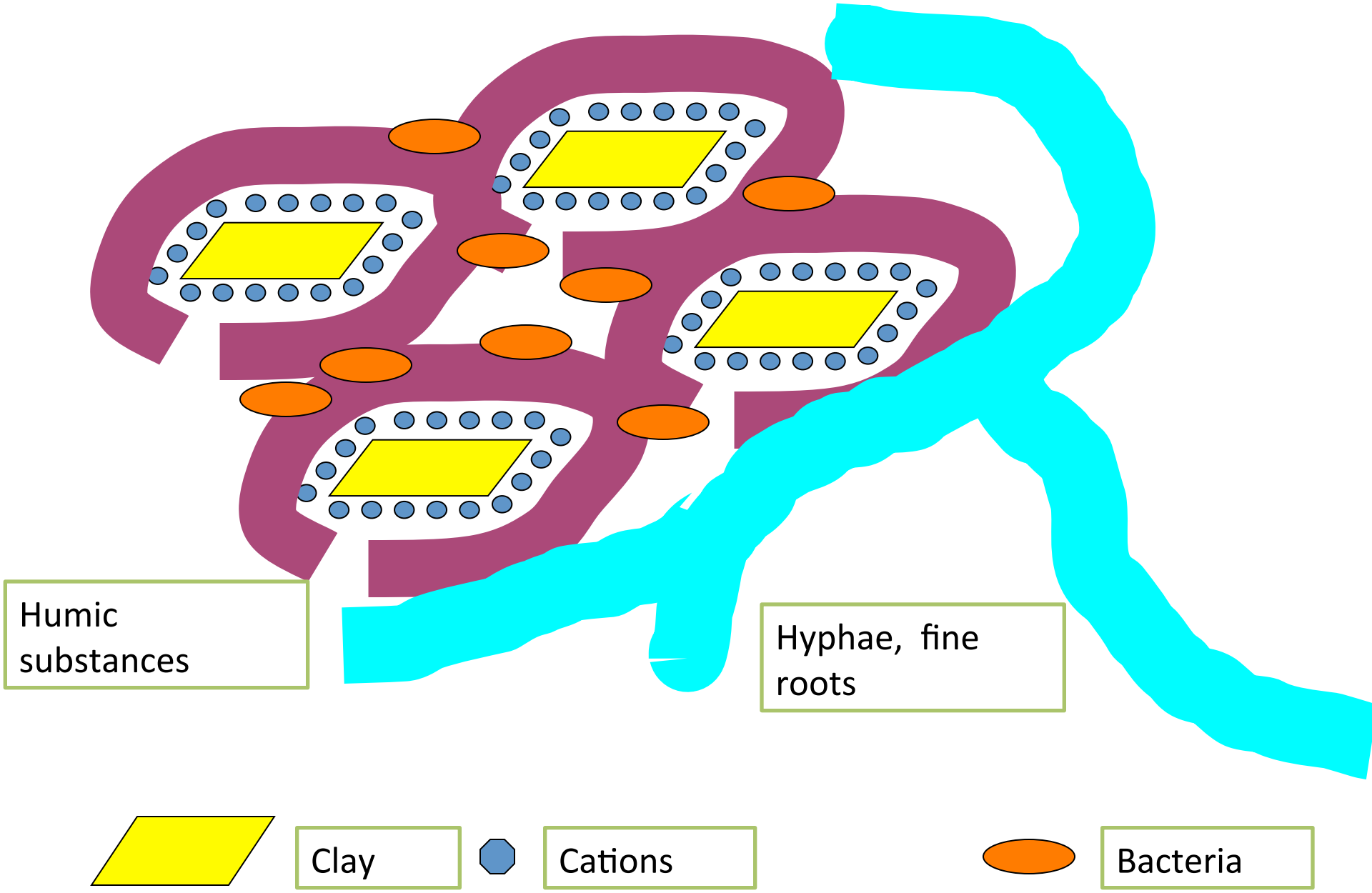
Aggregate structure
Aeration and Drainage
Mitigation of soil erosion
Soil water retention
Increase in specific heat
Increase in soil temperature



Hierarchical structure of soil aggregates

Forming process of soil aggregates





Mechanism of soil aggregate formation

Role of Mycorrhizal fungi

- Promotion of nutrient absorption
  （P absorption）
- Promotion of aggregate formation
  Large sized aggregate

b． **Improvements in chemical and biologicalproperties**

Retention of cations and anions
Transport and translocation of mineral nutrients
Binding and inactivation of harmful artificial organics
Mitigation of the effect of pollutants
Donor of Proton （H^+）
Physiologically active substances
Nutrient supply in good balance
Source of nutrients for
heterogeneous microbial communities
Competition with pathogenic germs

c . Plant growth promotion effects

Promotion of germination and root initiation
Promotion of the growth of root and stem
Complex formation with nutrient elements
Promotion of nutrient absorption by plants
Hormone-like activity
Promotion of permeability of cell membrane
Promotion of photosynthesis, respiration,
and enzyme activity
Suppress protein and increase sugar contents in plants

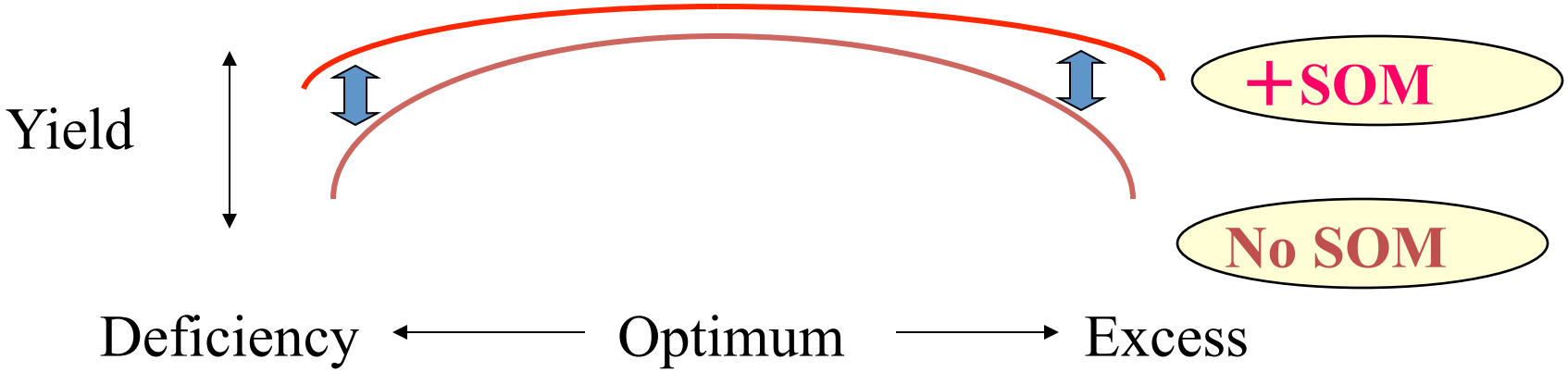
Alleviation of plant growth inhibition under
cold weather and irregular meteorological conditions

Plant growth promotion effects

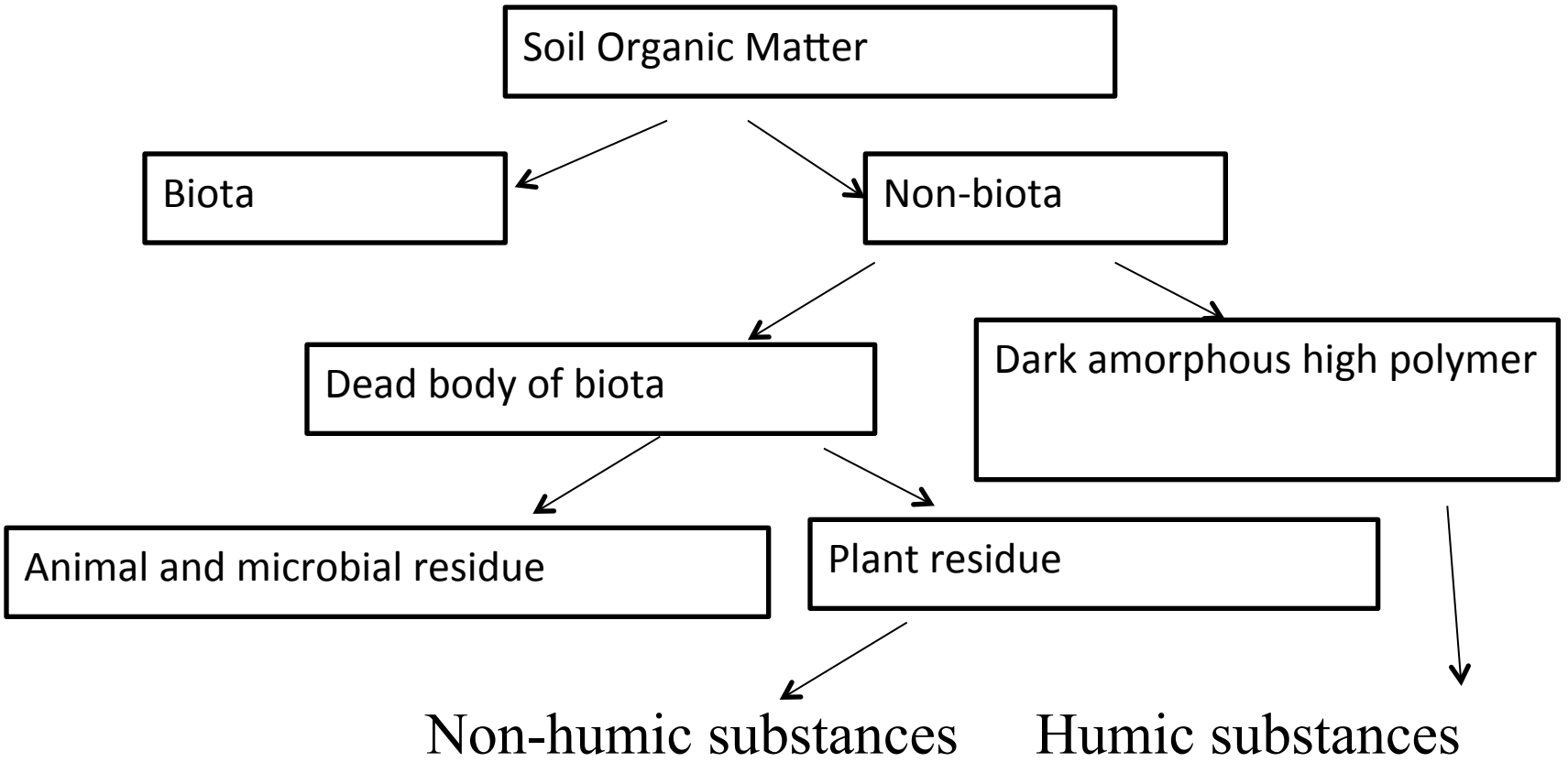
Plant hormone activity

Cold tolerance

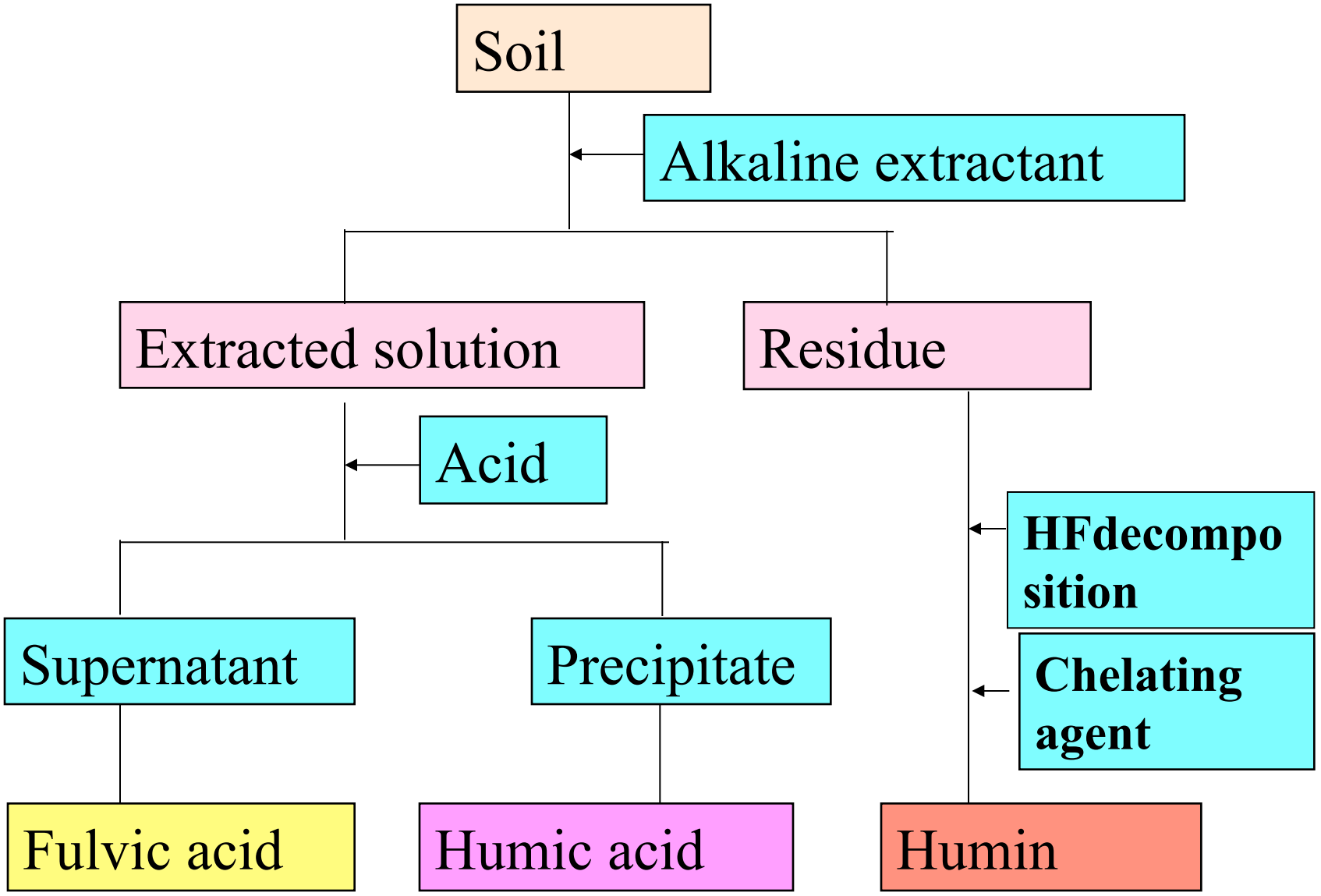
Stable production under deficiency and excess of nutrients



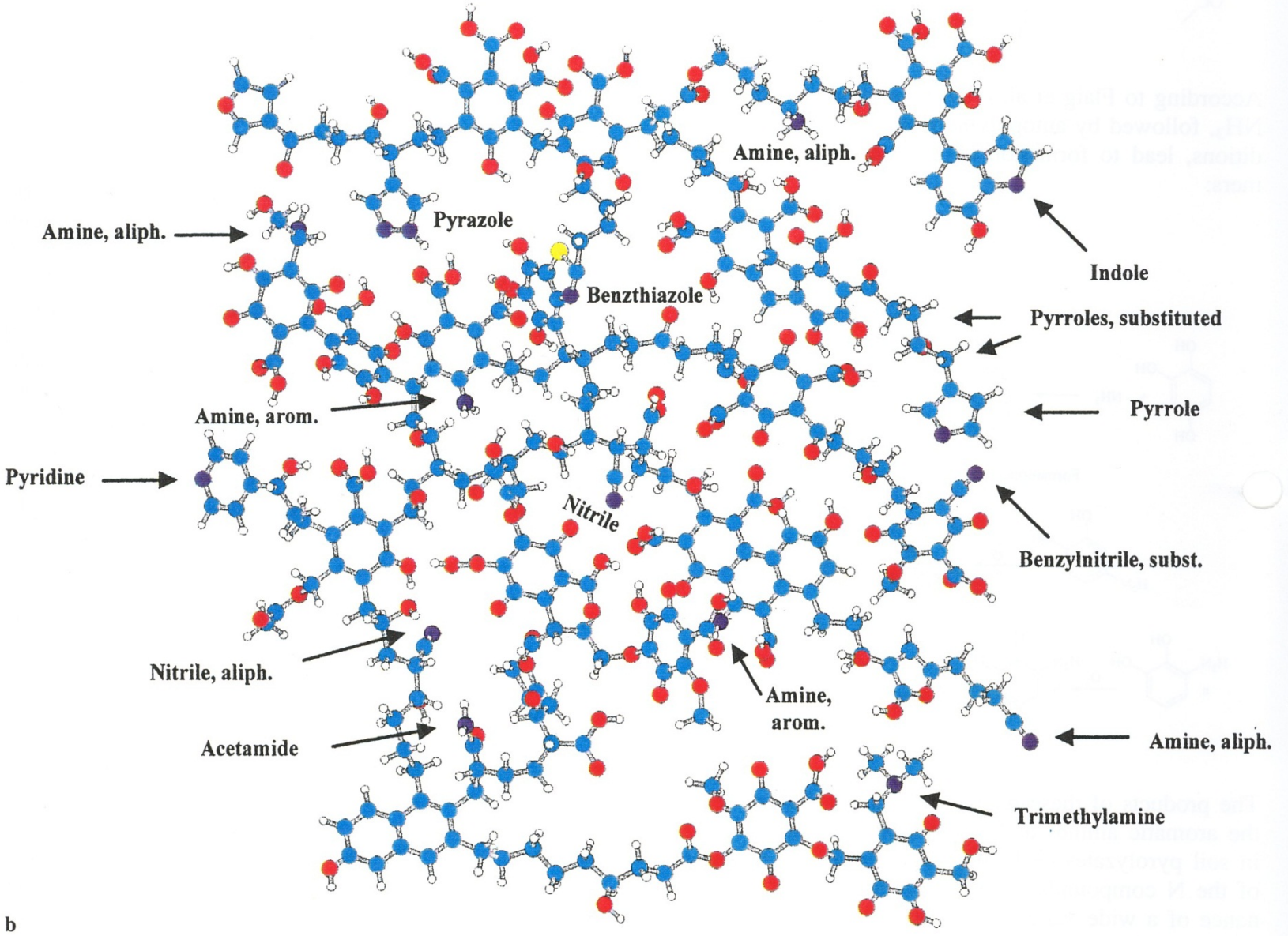
Characterization of soil organic matter



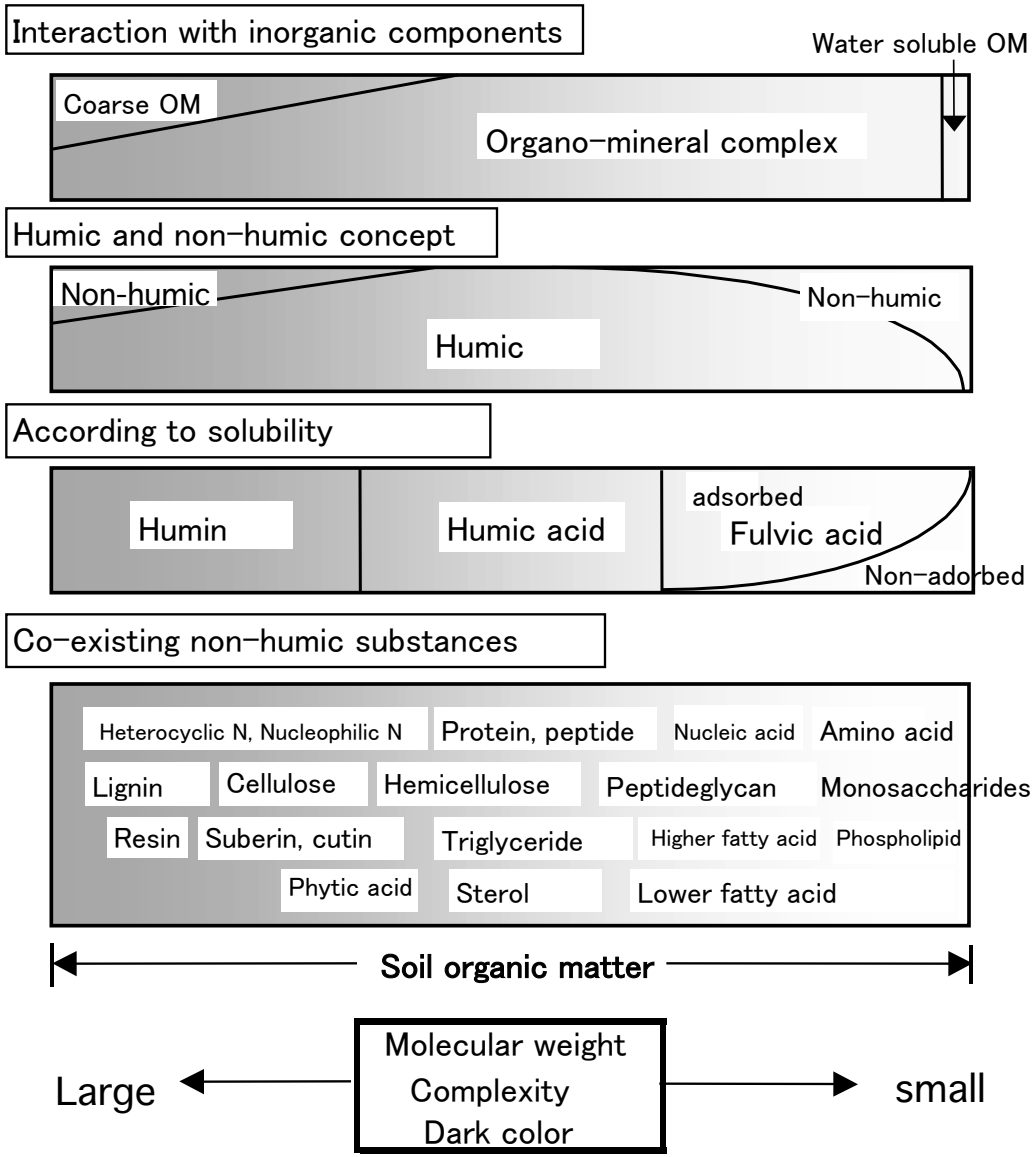
Division of soil organic matter（Takai, 1977）



Fractionation of humic substances



Proposed molecular structure of humic acid



Chemical composition of soil organic matter

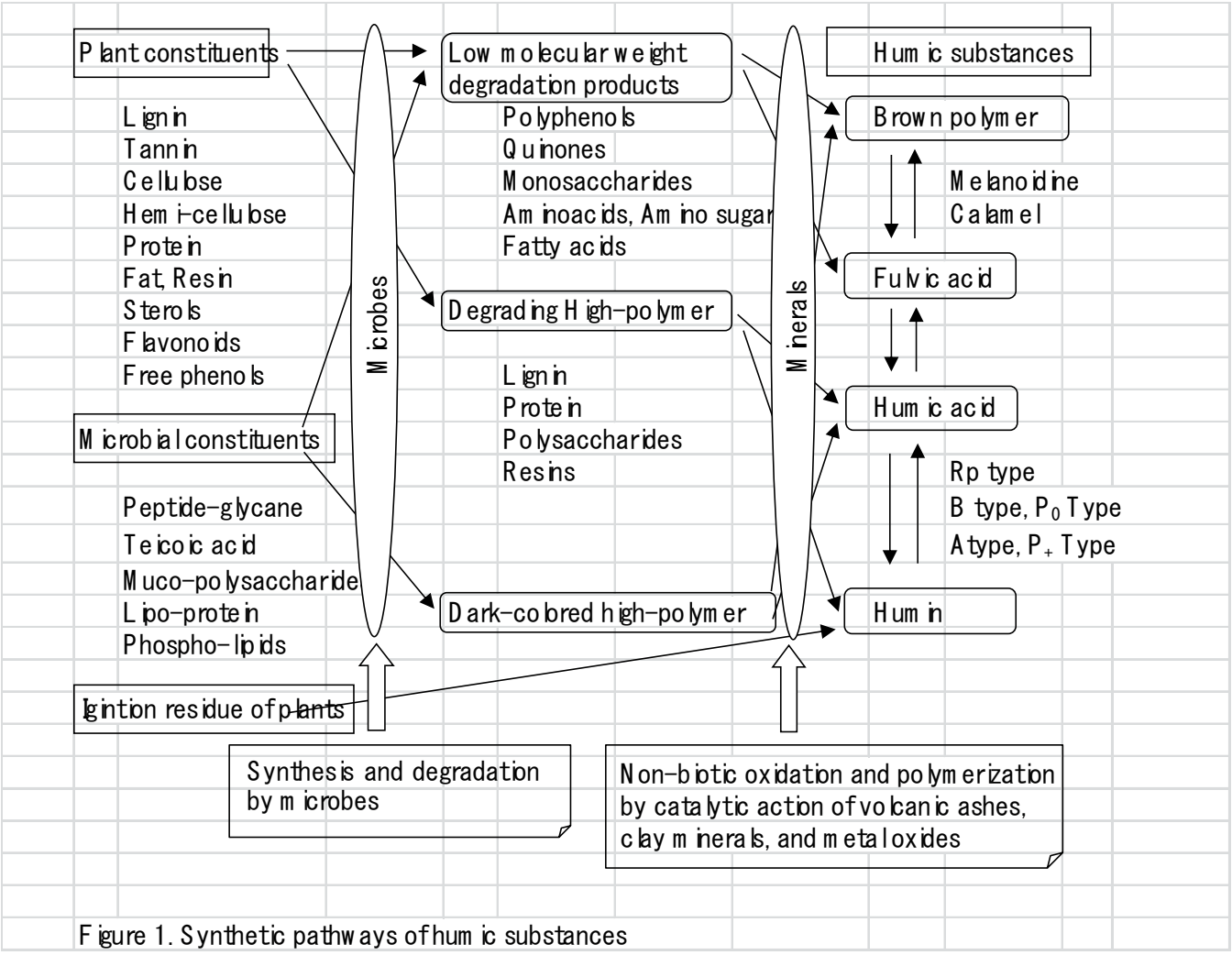
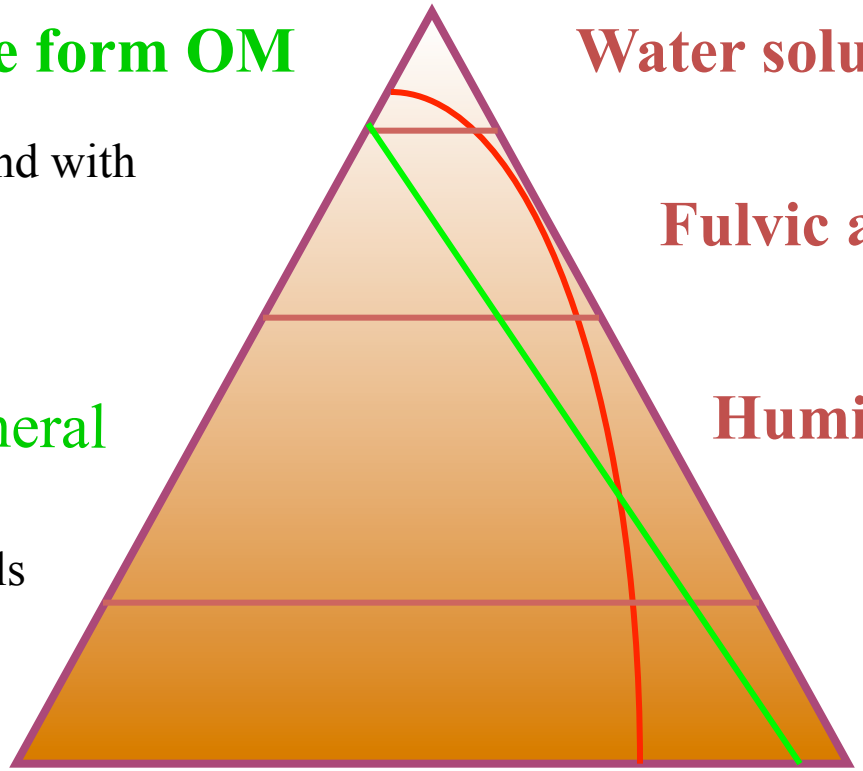


Figure 1. Synthetic pathways of humic substances



Free form OM

Not bound with minerals

Water soluble OM

Soluble in water

Fulvic acid

Soluble in acid and alkaline

Humic acid

Precipitate with acid

Organo-mineral complexes

Bound with minerals

Humin

Not soluble in alkali or acid

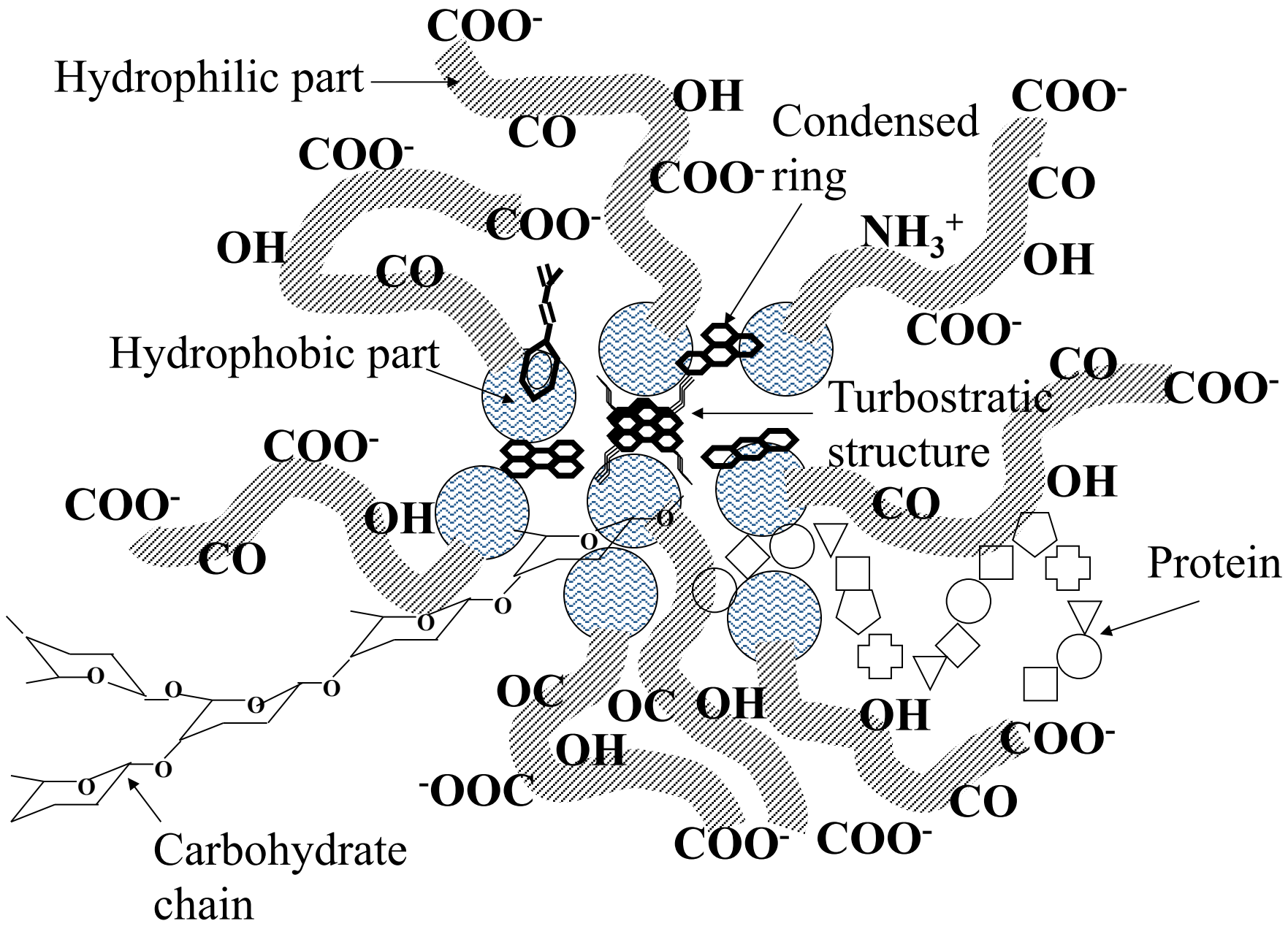
Humic substance

Dark colored, amorphous high polymer

Non-humic

OM with known structure

Concept on soil organic matter



Structural concept of humic substances

Synthetic expression of elementary composition of humic substances

- As indices for expressing elementary composition synthetically, following ratios are calculated. Elementary number is used in the calculation.

Combustion Quotient

- Combustion quotient (CQ) is a theoretical value for respiration quotient as proposed by Tamiya [5)]
- $CQ = 4C / (4C + H - 3N - 2O)$ ------ (1)

Degree of Unsaturation

- Degree of unsaturation (DU) shows the number of unsaturated bonds and ring bonds per 100 carbon atoms.
- DUH = (2C + N — H) / 2C × 100 ------ (2)

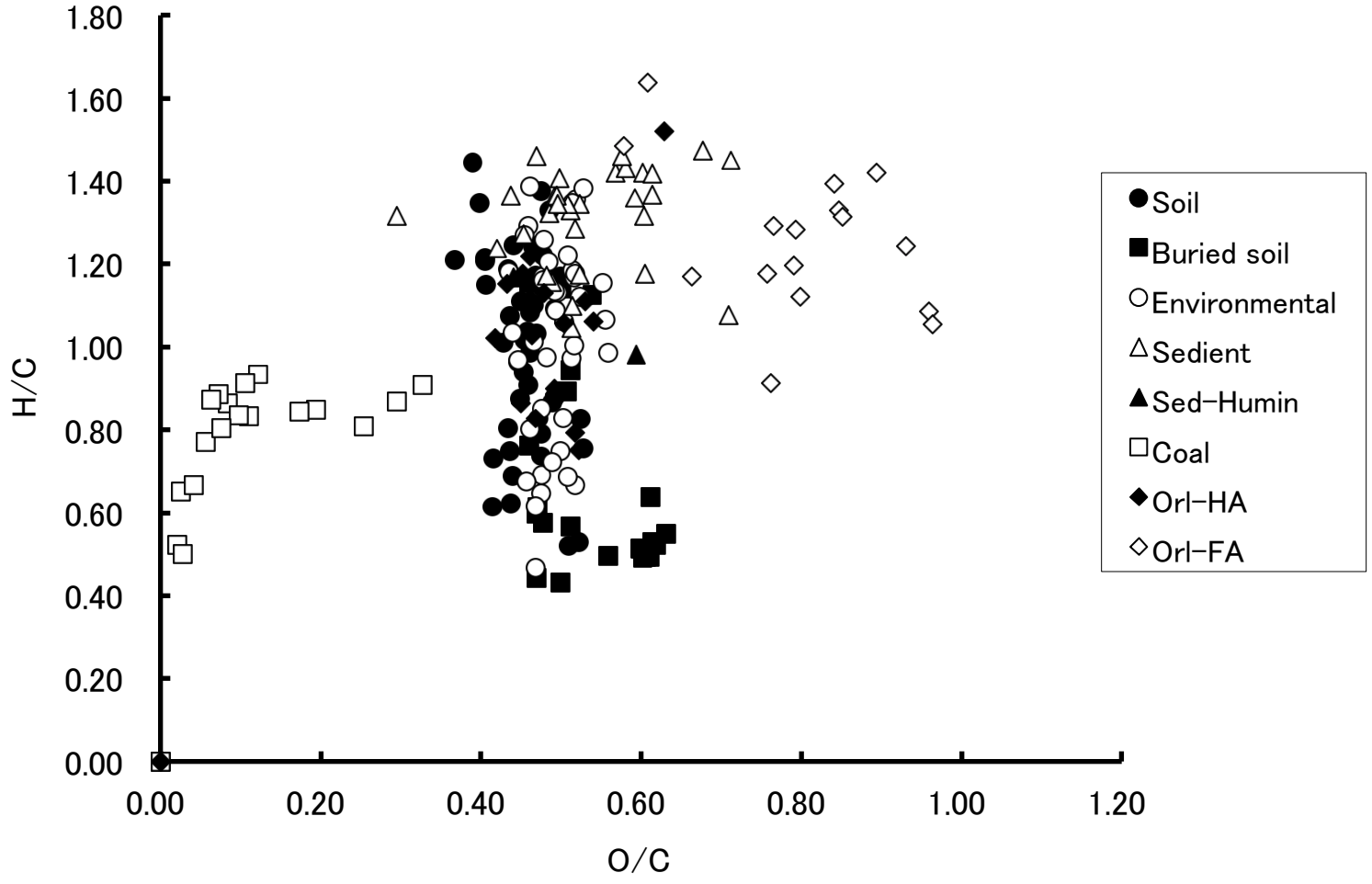
Degree of Oxidation (ω)

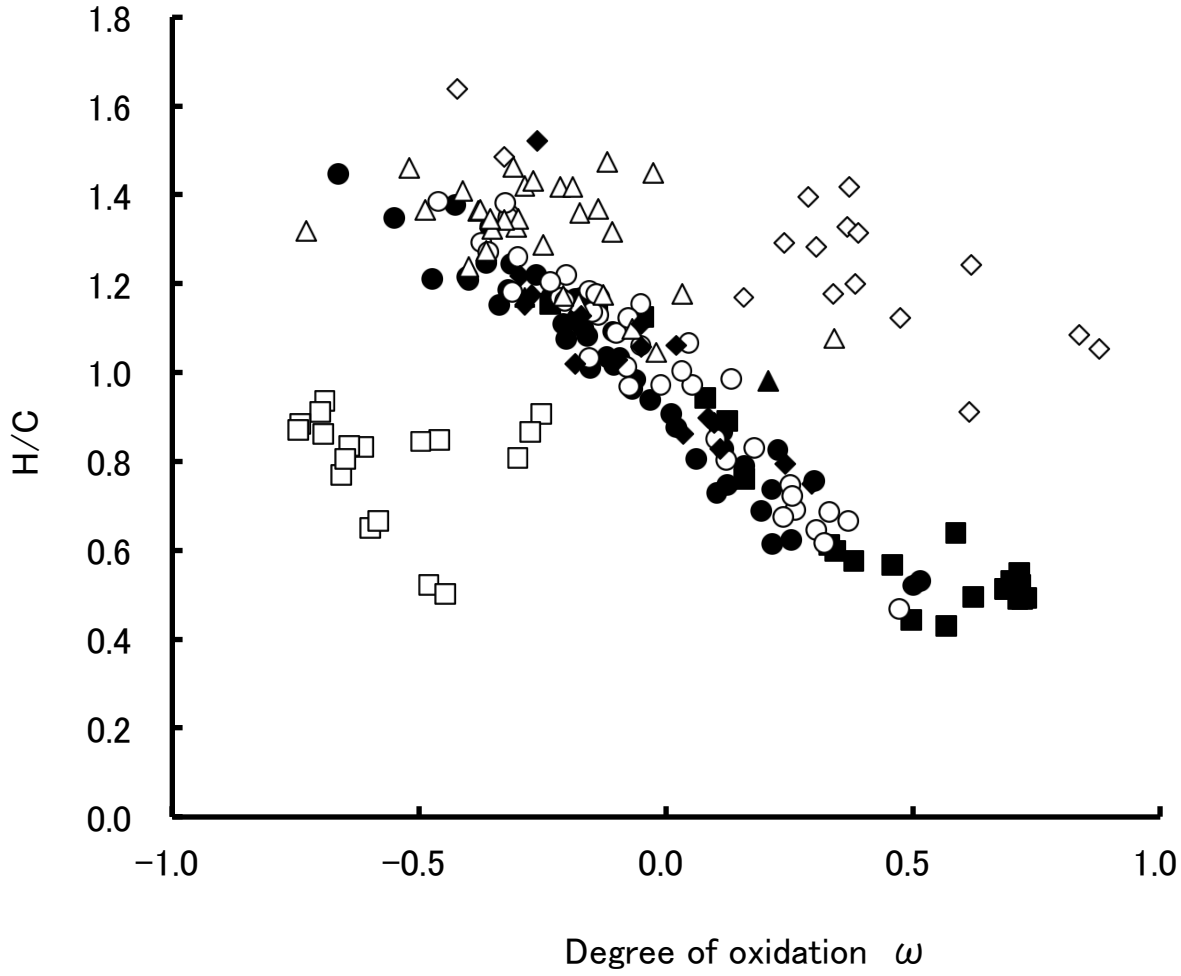
$\omega = (2O - H)/C$ ------ (3)

shows the excess or deficit of oxygen and hydrogen in comparison with $C_n(H_2O)_n$

- This value is distributed between −0.8 and +0.9 for humic substances.

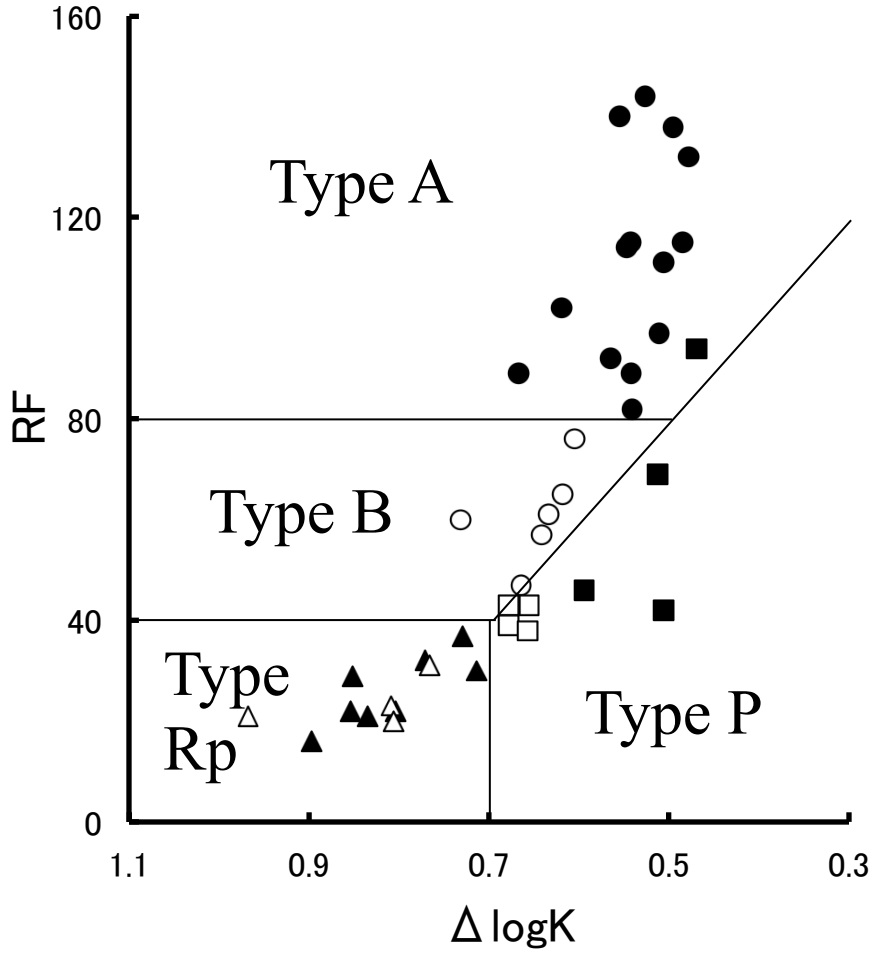
Elementary composition of humic substances H/C and O/C





Degree of oxidation(ω) and H/C

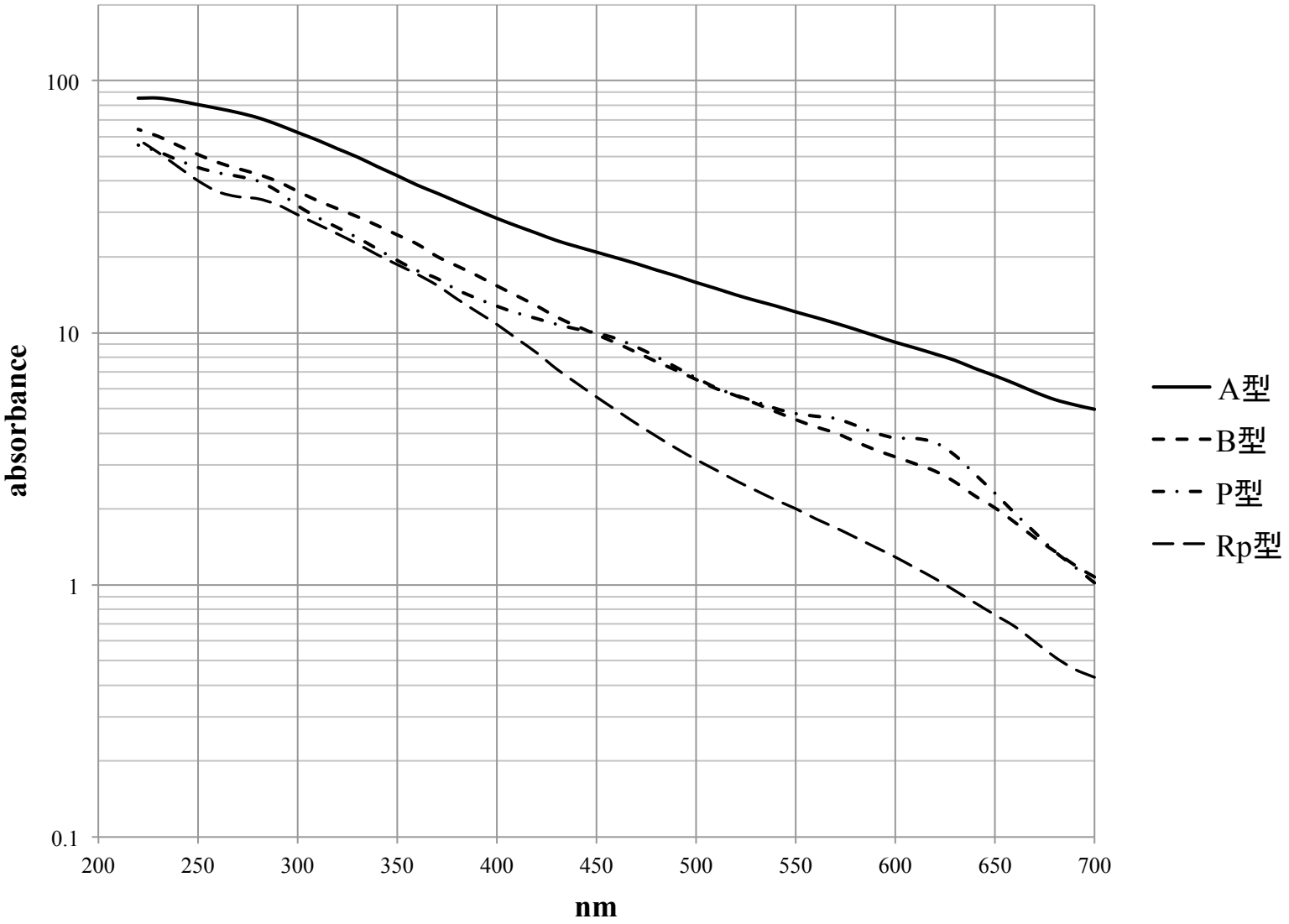
● soil humic acids from literature 3 ■ humic acids from buried volcanic ash sois、○ humic asids from literature 7, △ humic acids from sea and lake sediments, ▲ humin from sediments, □ coal, ◆ humic acids from Russian soils in literature 6 ◇fulvic acids from Russian soils.



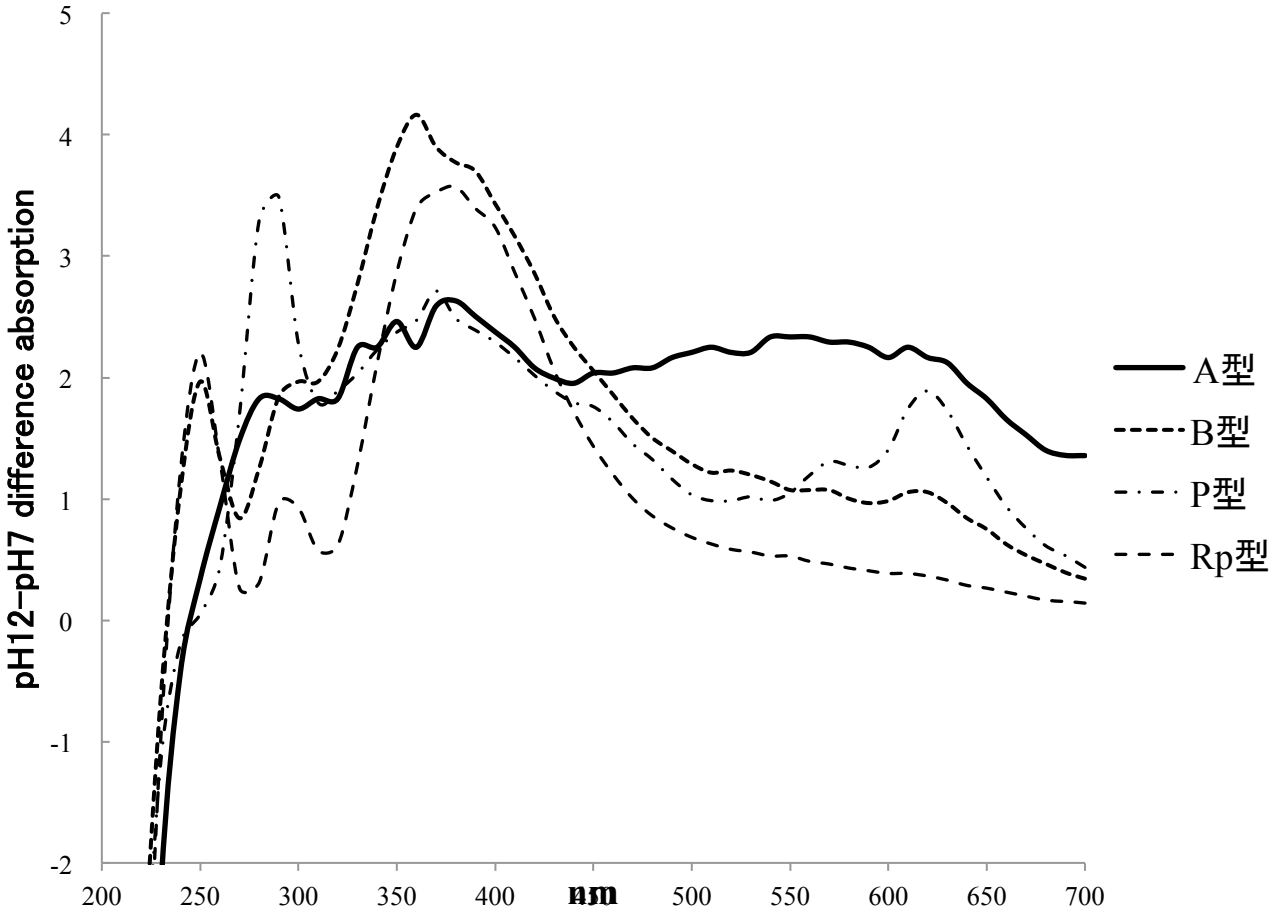
Classification of humic substances by RF and ΔlogK

● Type A, ○ Type B, ■ Type P with obvious Pg absorption, □ Type P without Pg absorption

▲ Type Rp from mineral soil, △ Type Rp from O layer



UV-vis. Absorption spectra of humic acis in different types
Type A　Inogashira (volcanic ash soil), Type B Higashiyama (brown forest soil),
Type P Tsubame (Pg of buried soil), Type Rp Anjo (paddy soil)
Concentrations are adjusted to 1mgC mL^{-1}



pH12-pH7 difference absorption spectra of different types of humic acids.
（Same humic acids as in the previous figure）