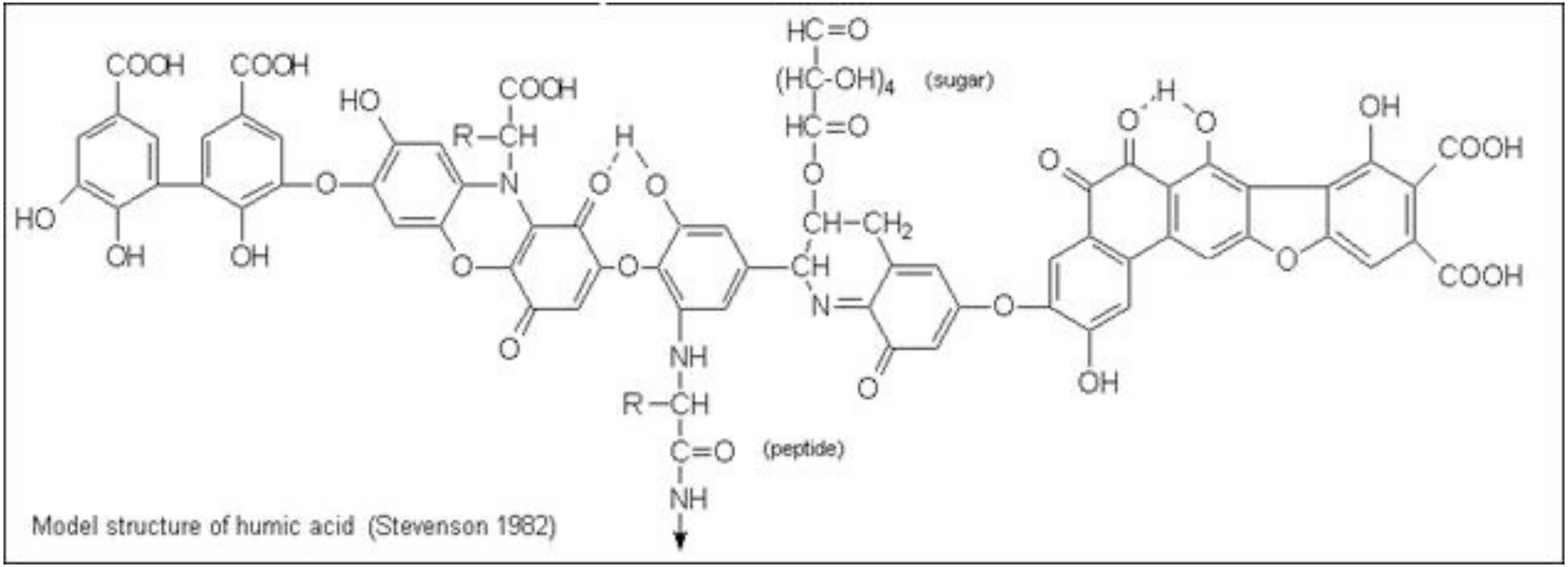
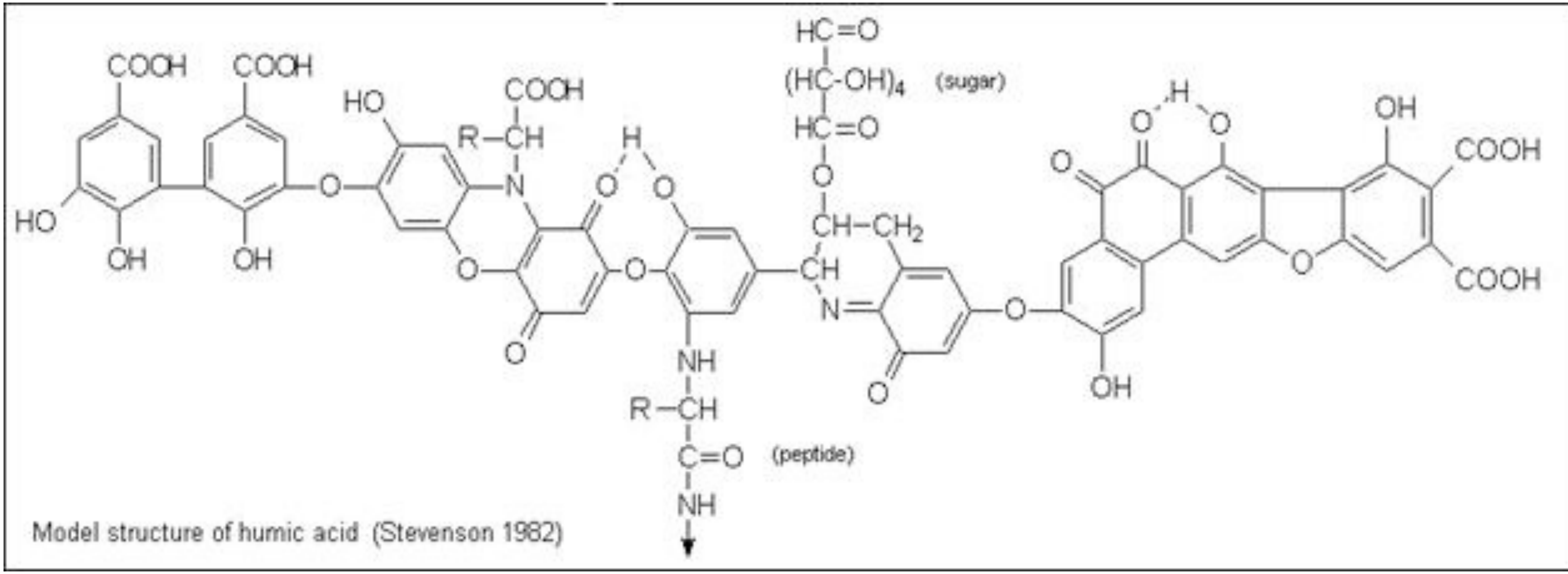
Soil Fertility

Soil Fertility

A few basic points …

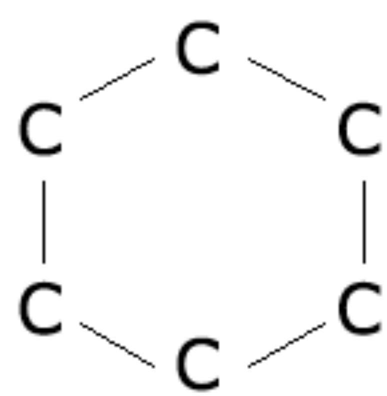

COOH
COOH
HO
COOH
R–CH
N
H
O
O
HC=O
(HC-OH)4
(sugar)
HC=O
O
CH–CH2
CH
N=
O
H
O
OH
COOH
COOH
HO
OH
OH
O
O
O
O
NH
R–CH
C=O
(peptide)
NH
OH
Model structure of humic acid (Stevenson 1982)

Humic Acid



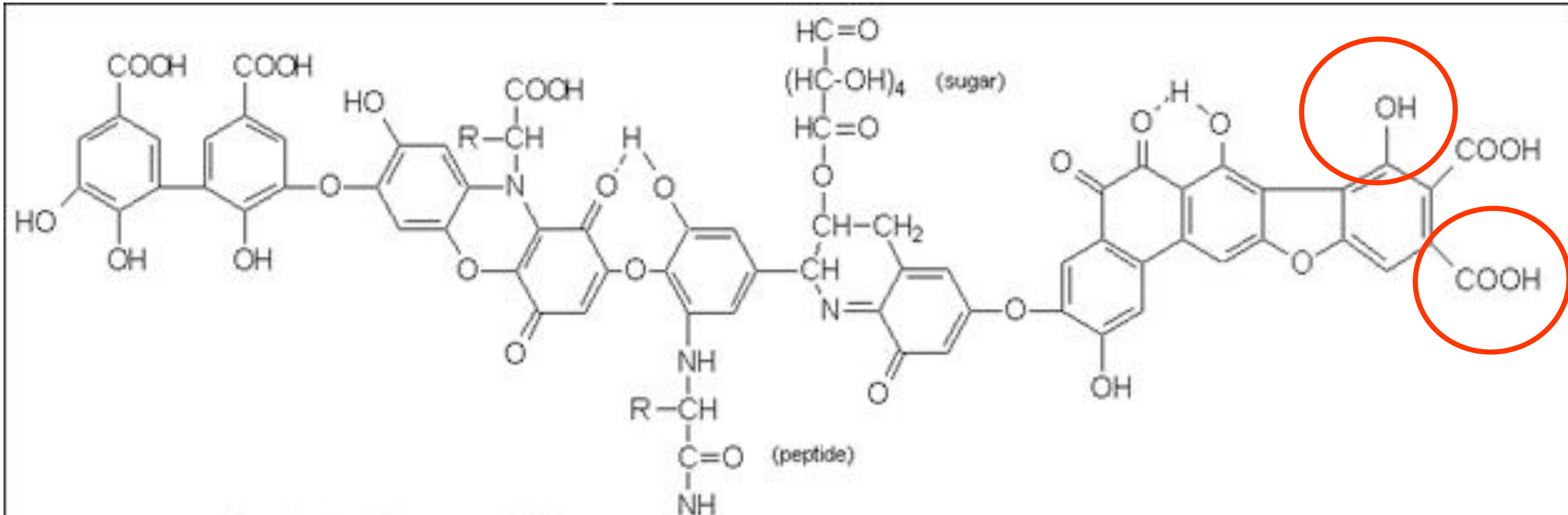
Model structure of humic acid (Stevenson 1982)

Humic Acid



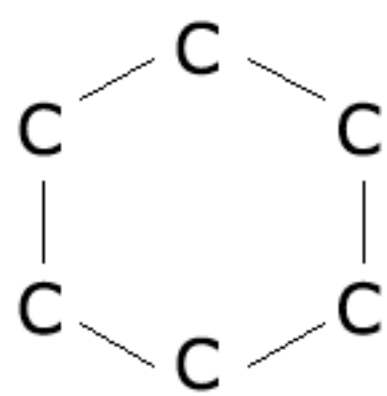
Aromatic rings

Basic building blocks
of humic acid



Model structure of humic acid (Stevenson 1982)

Humic Acid



Aromatic rings

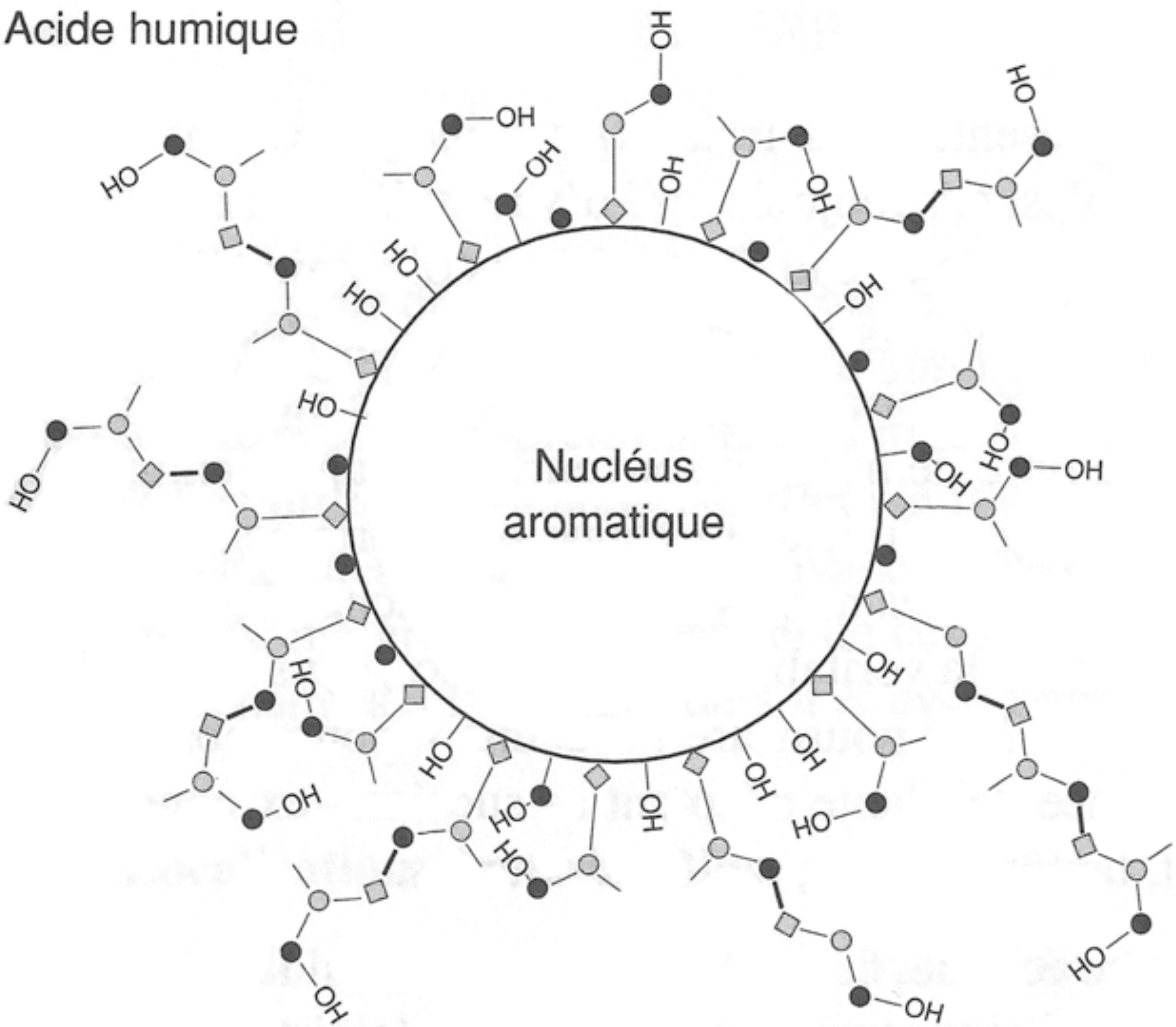
Basic building blocks
of humic acid

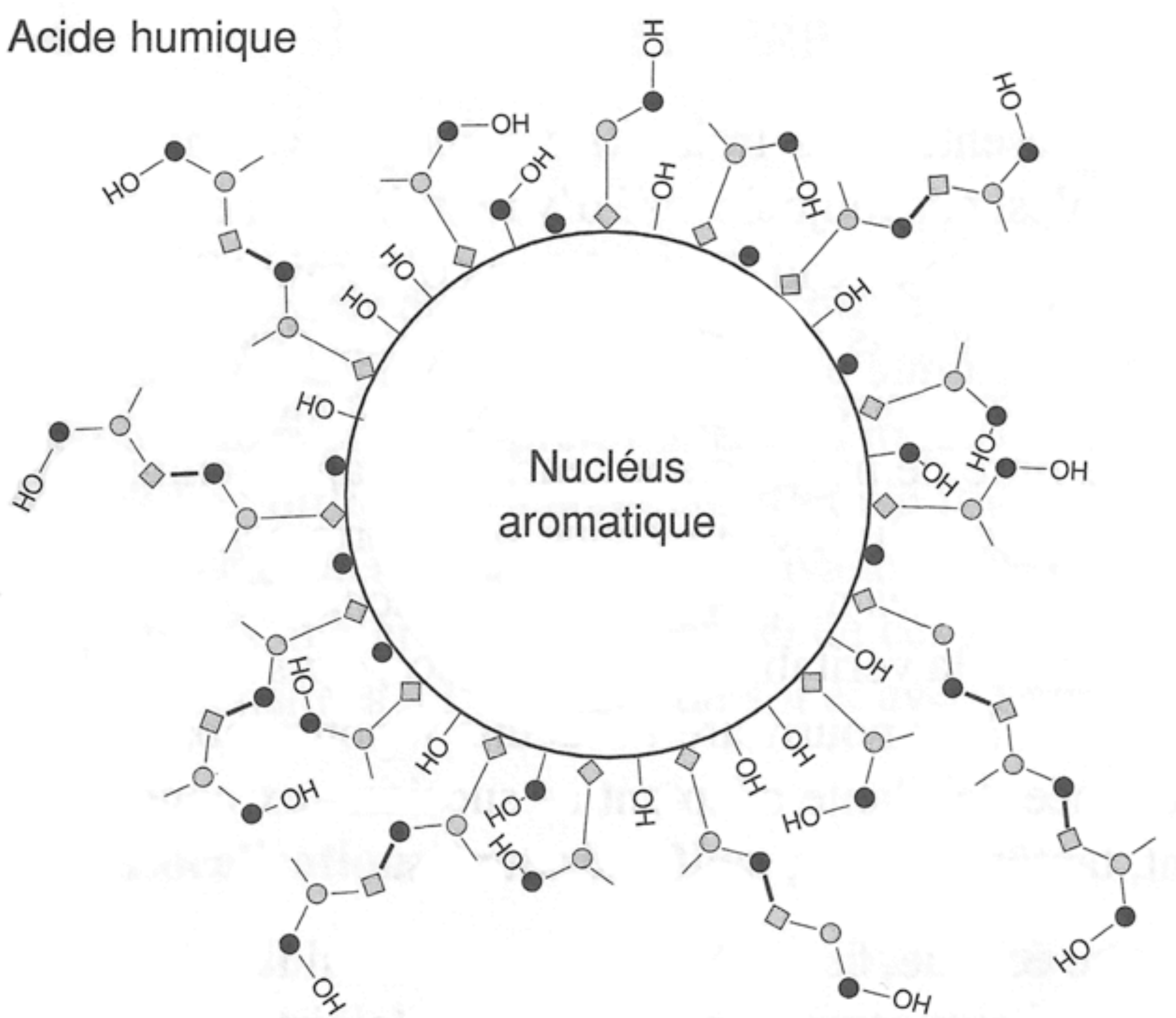
Functional groups

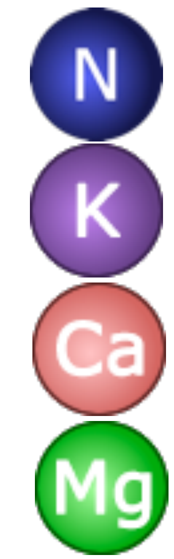
“Loci of chemical and
electrostatic interaction”

OH - Hydroxyl group
COOH - Carboxyl group

Acide humique





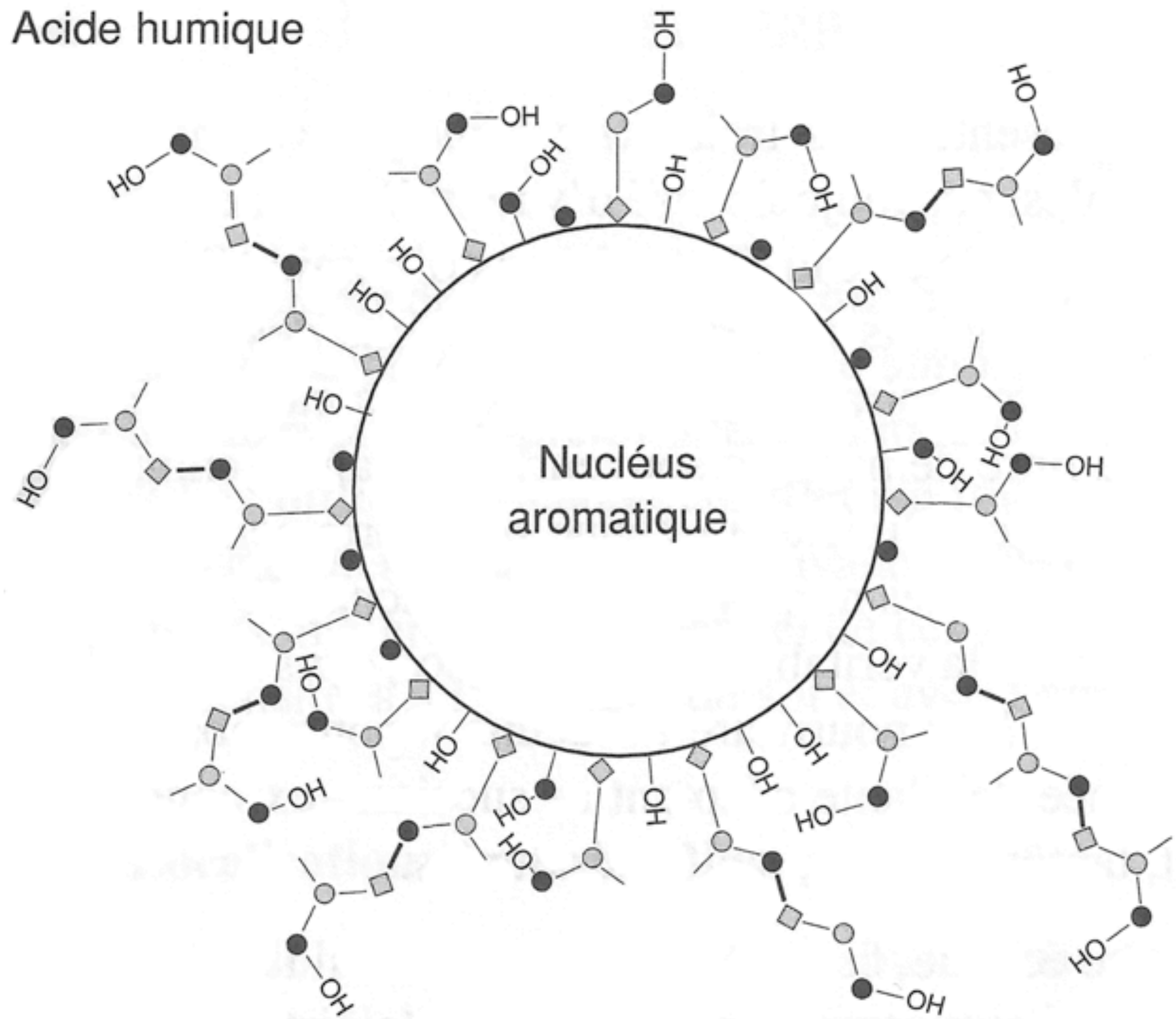


Nitrogen

Potassium

Calcium

Magnesium

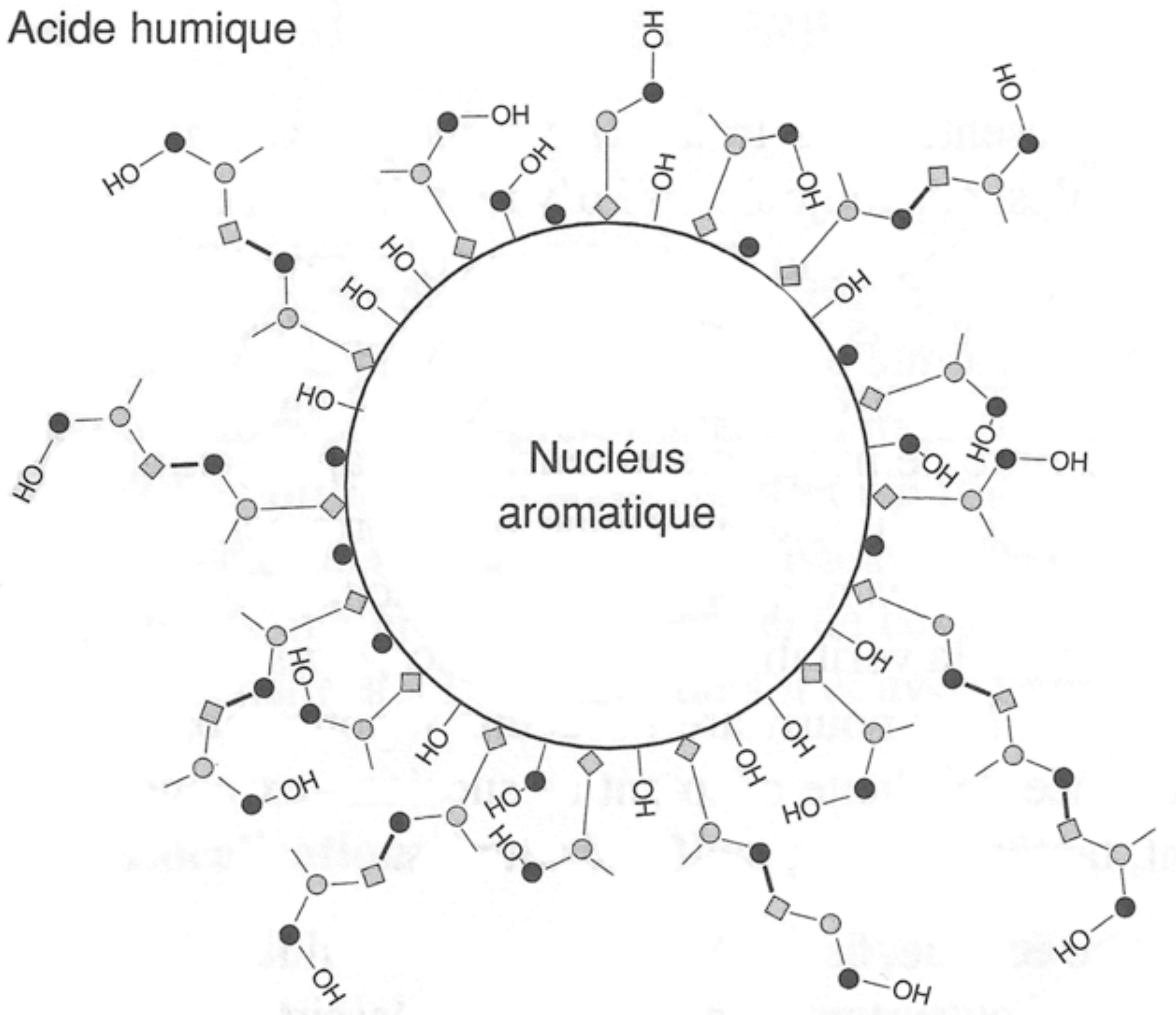


+ N Nitrogen

+ K Potassium

+ Ca Calcium

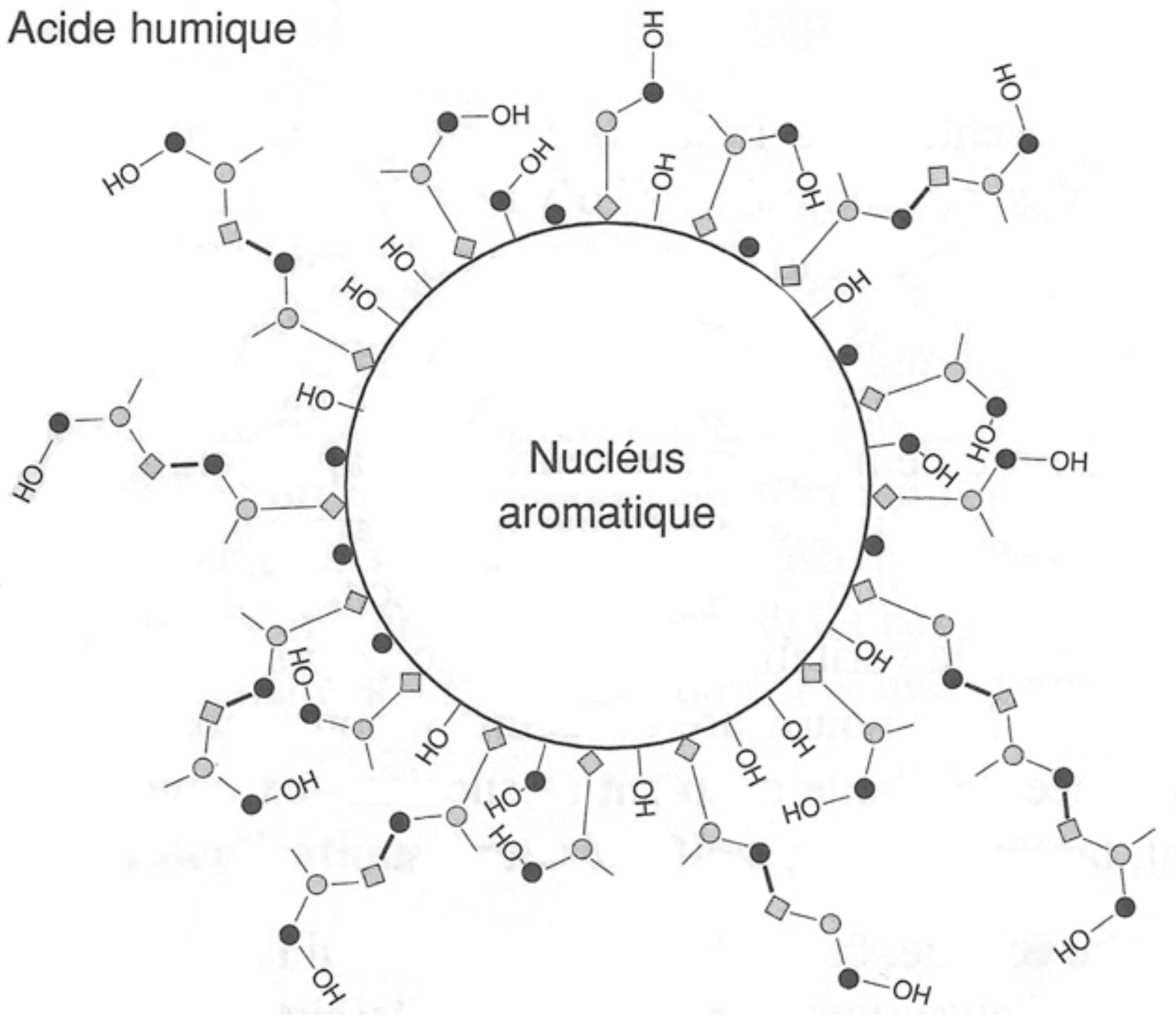
+ Mg Magnesium

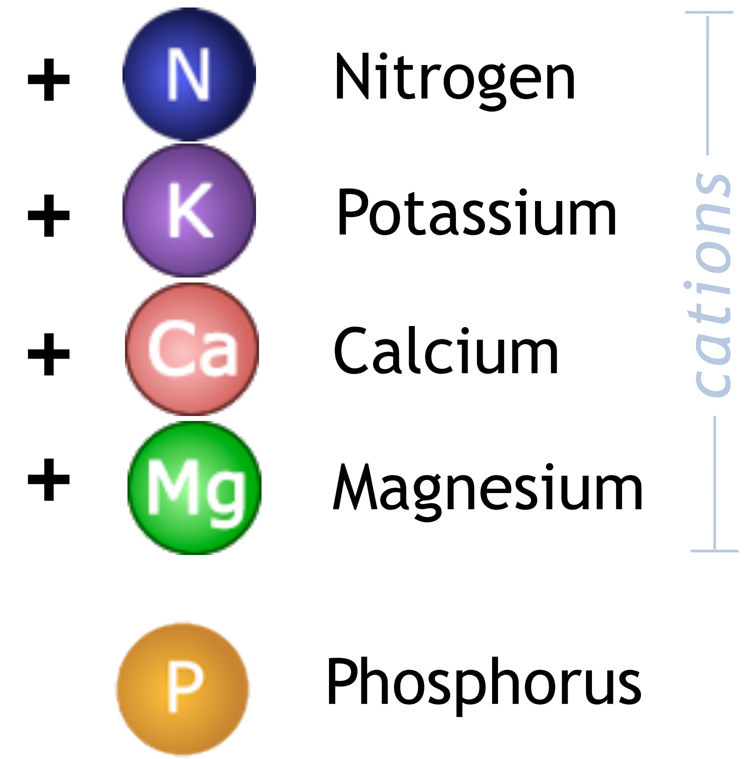


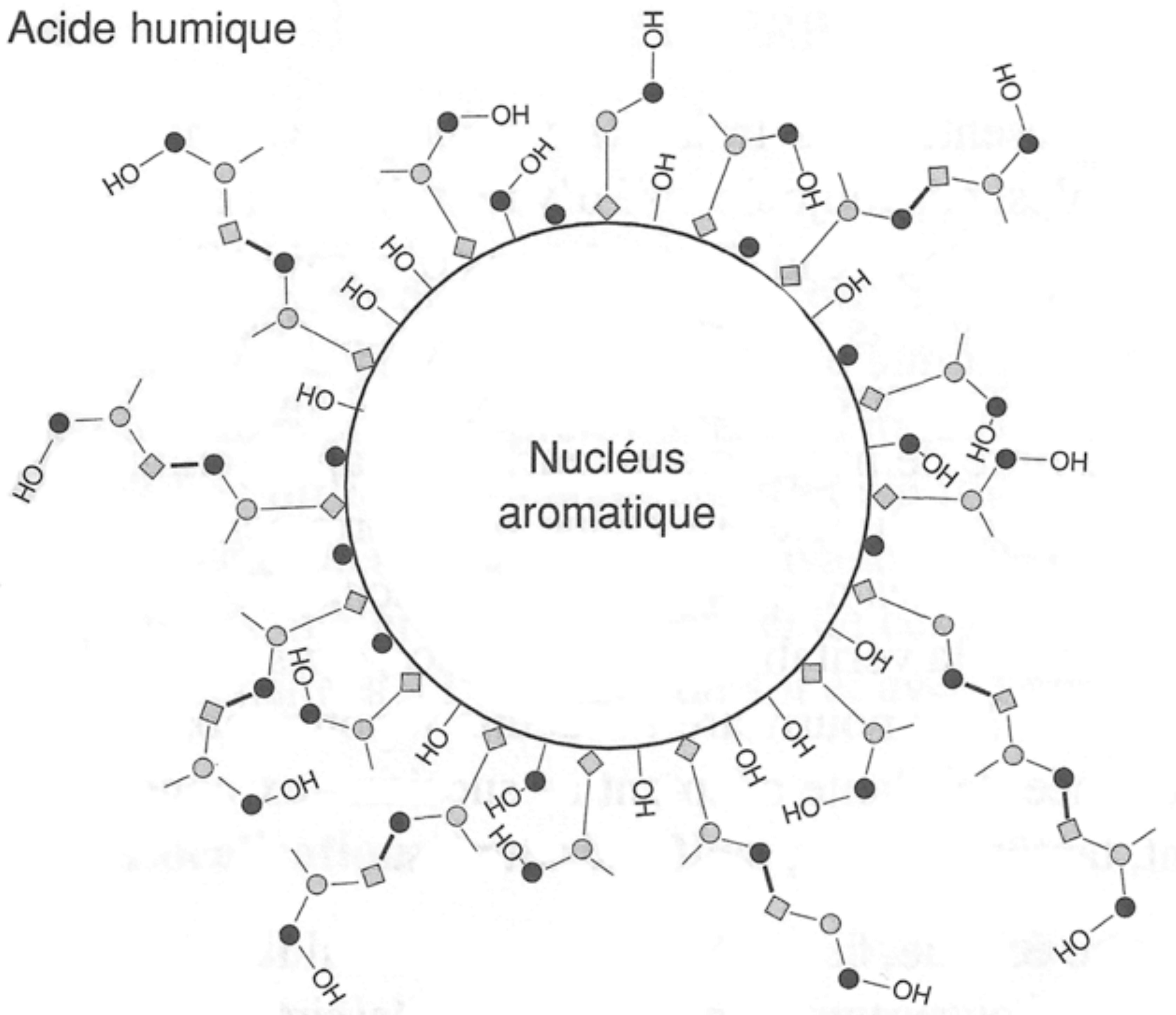
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium

cations

Acide humique

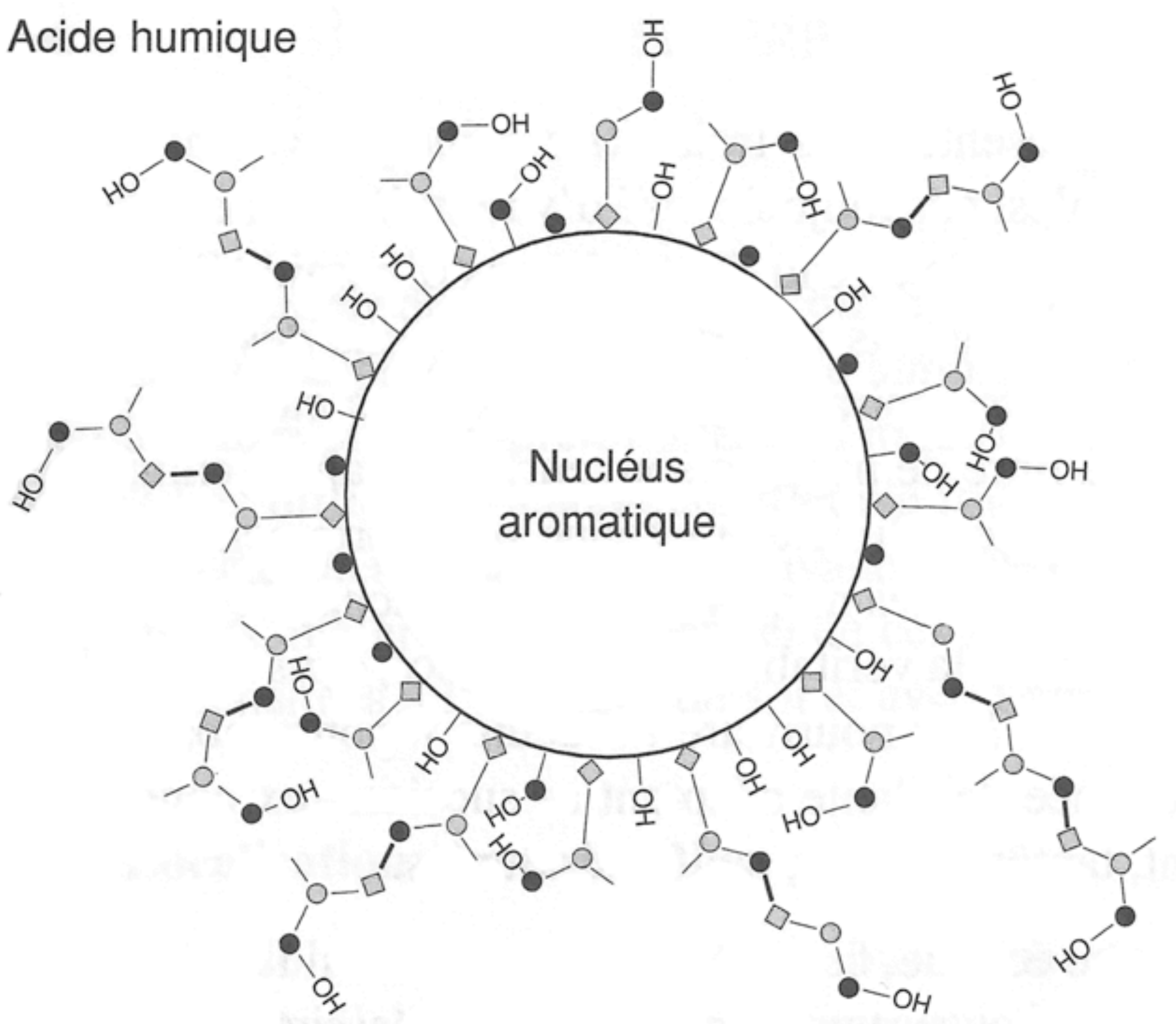






+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
- P Phosphorus

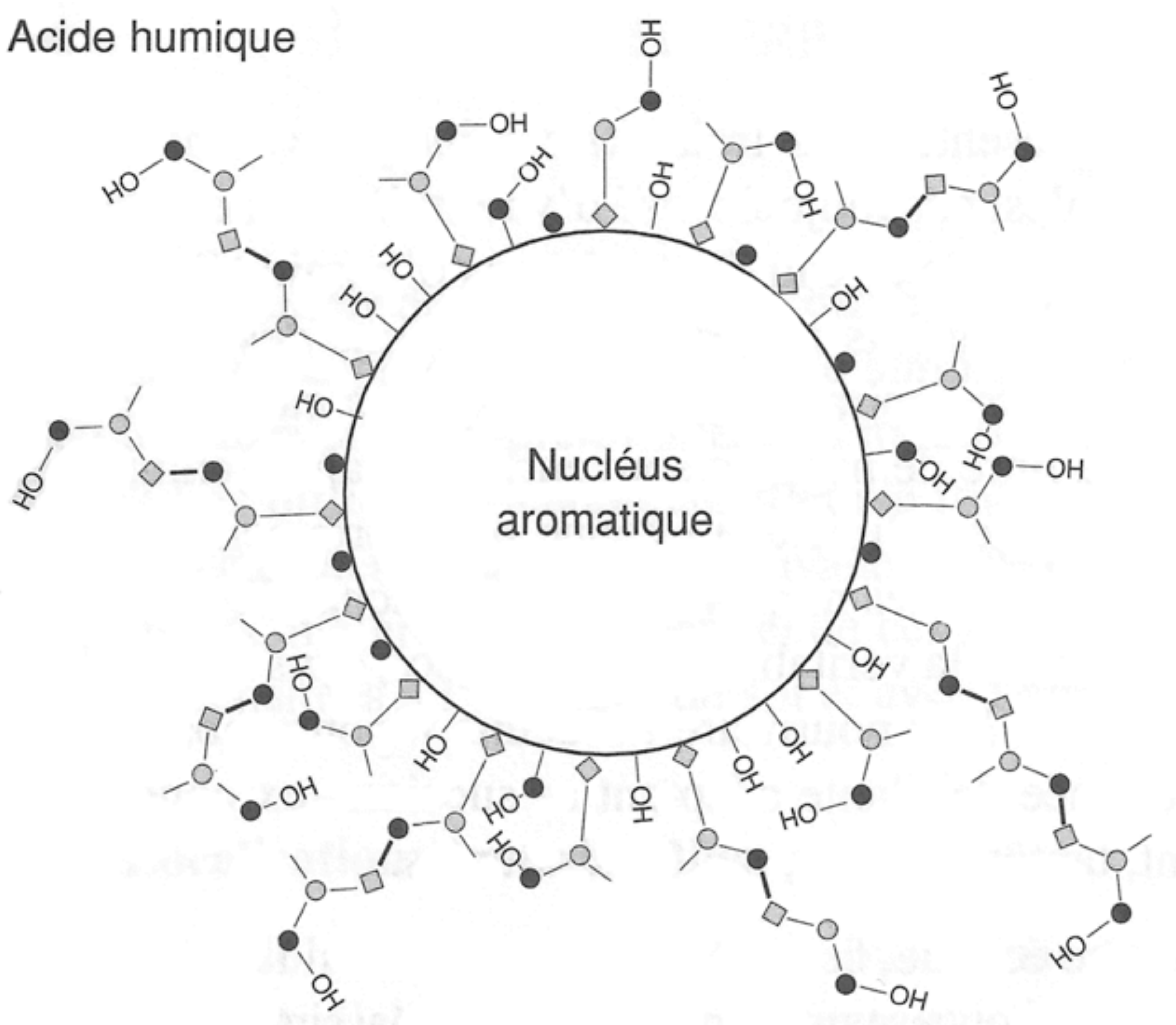
cations

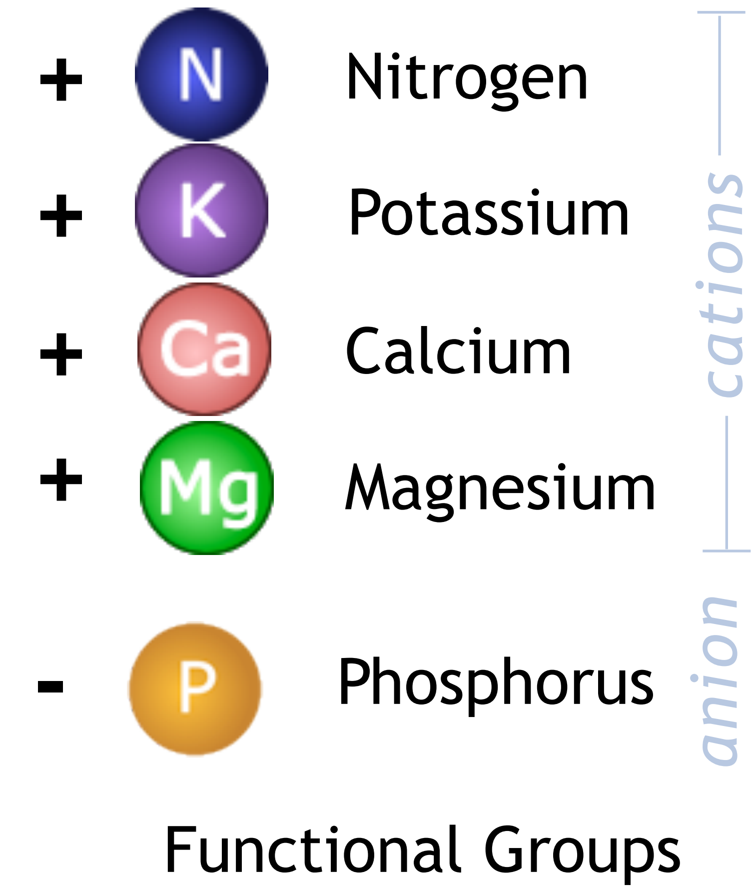


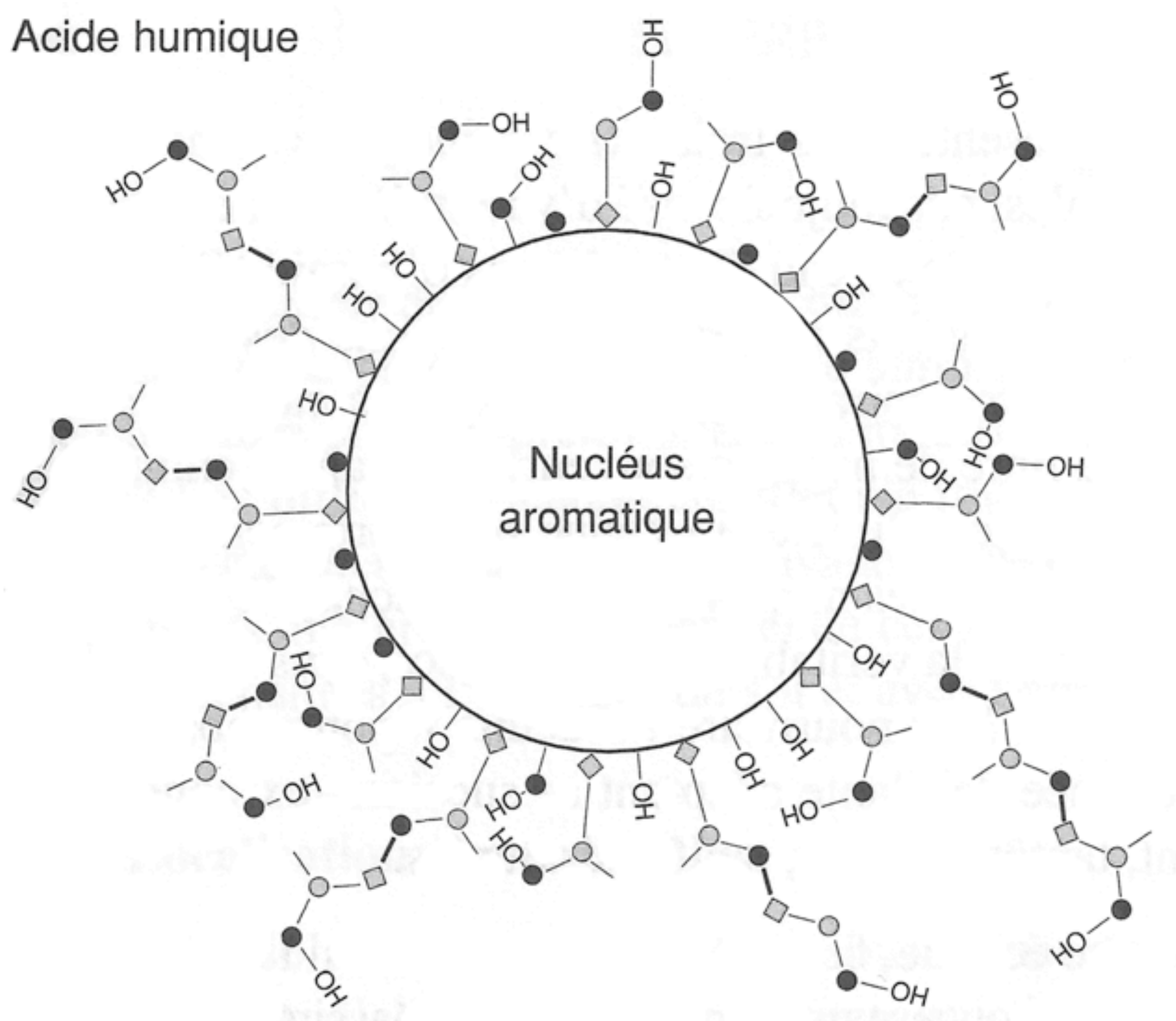
- \+ N Nitrogen
- \+ K Potassium
- \+ Ca Calcium
- \+ Mg Magnesium
- \- P Phosphorus

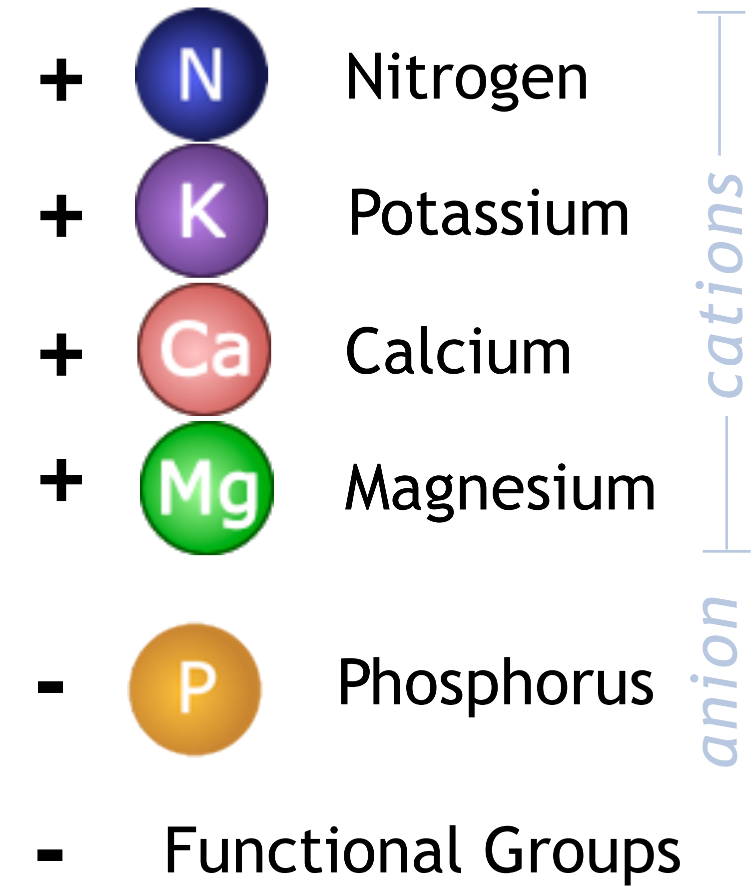
cations

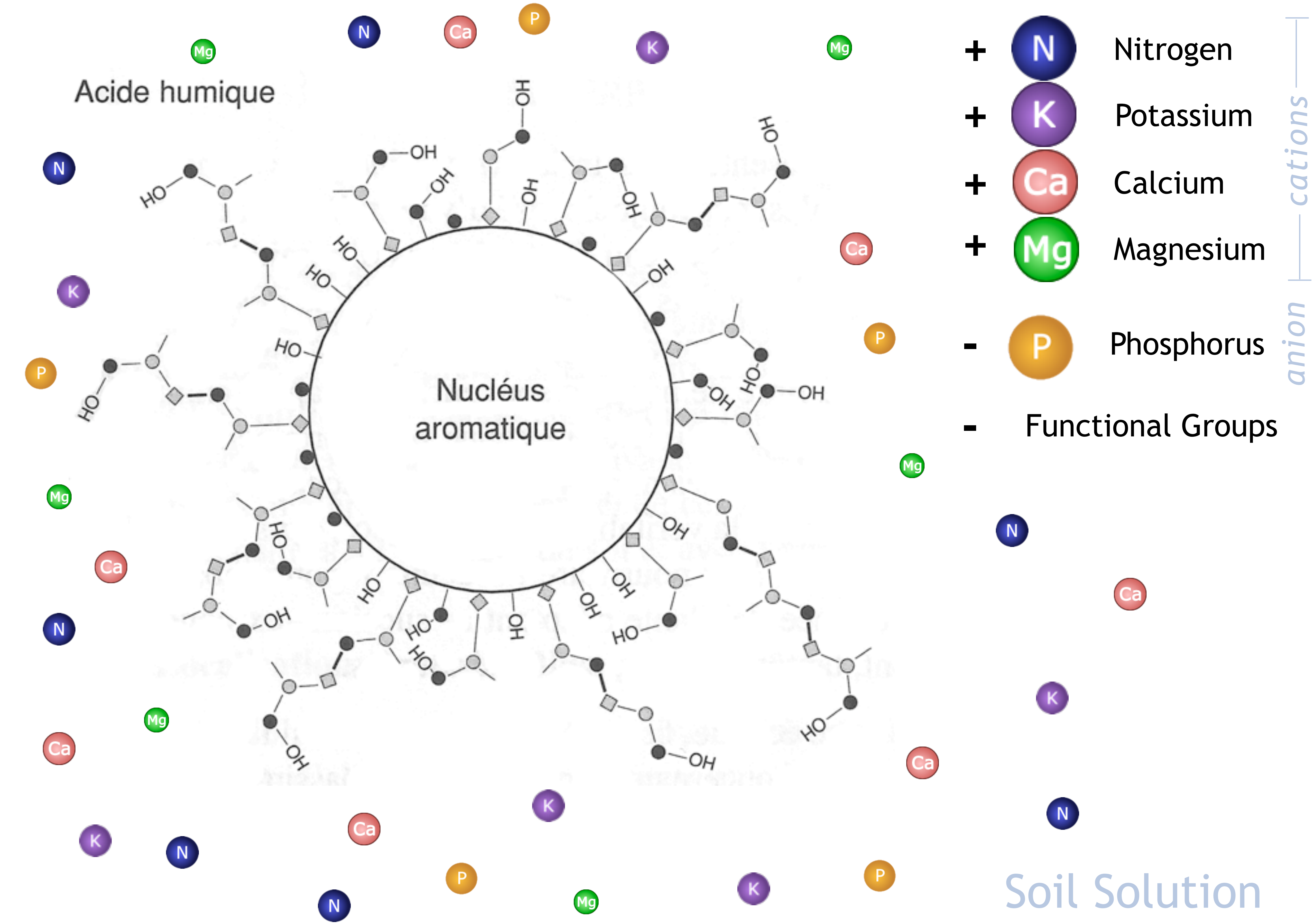
anion


Acide humique
Nucléus
aromatique

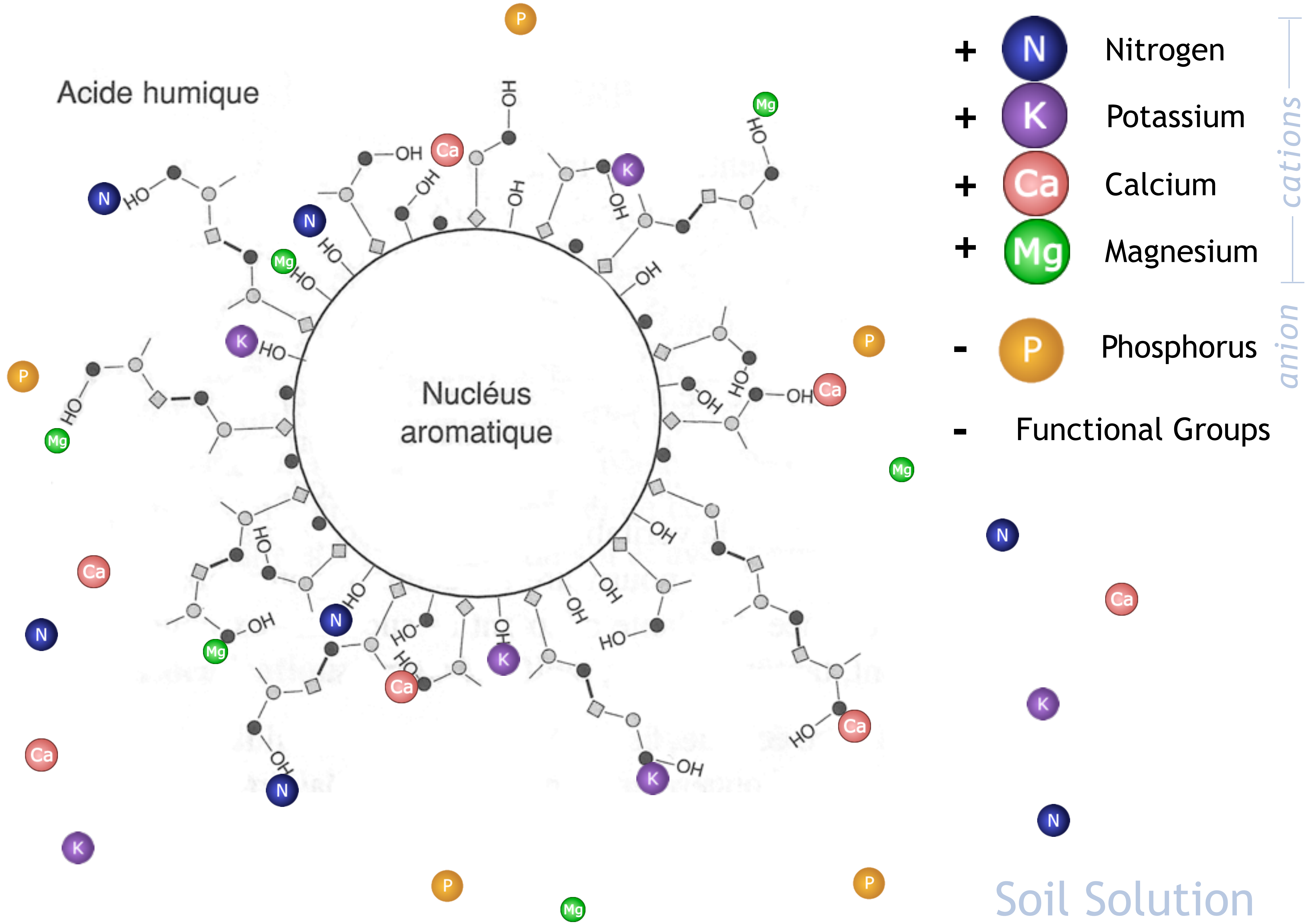

+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
cations
- P Phosphorus
anion
Functional Groups

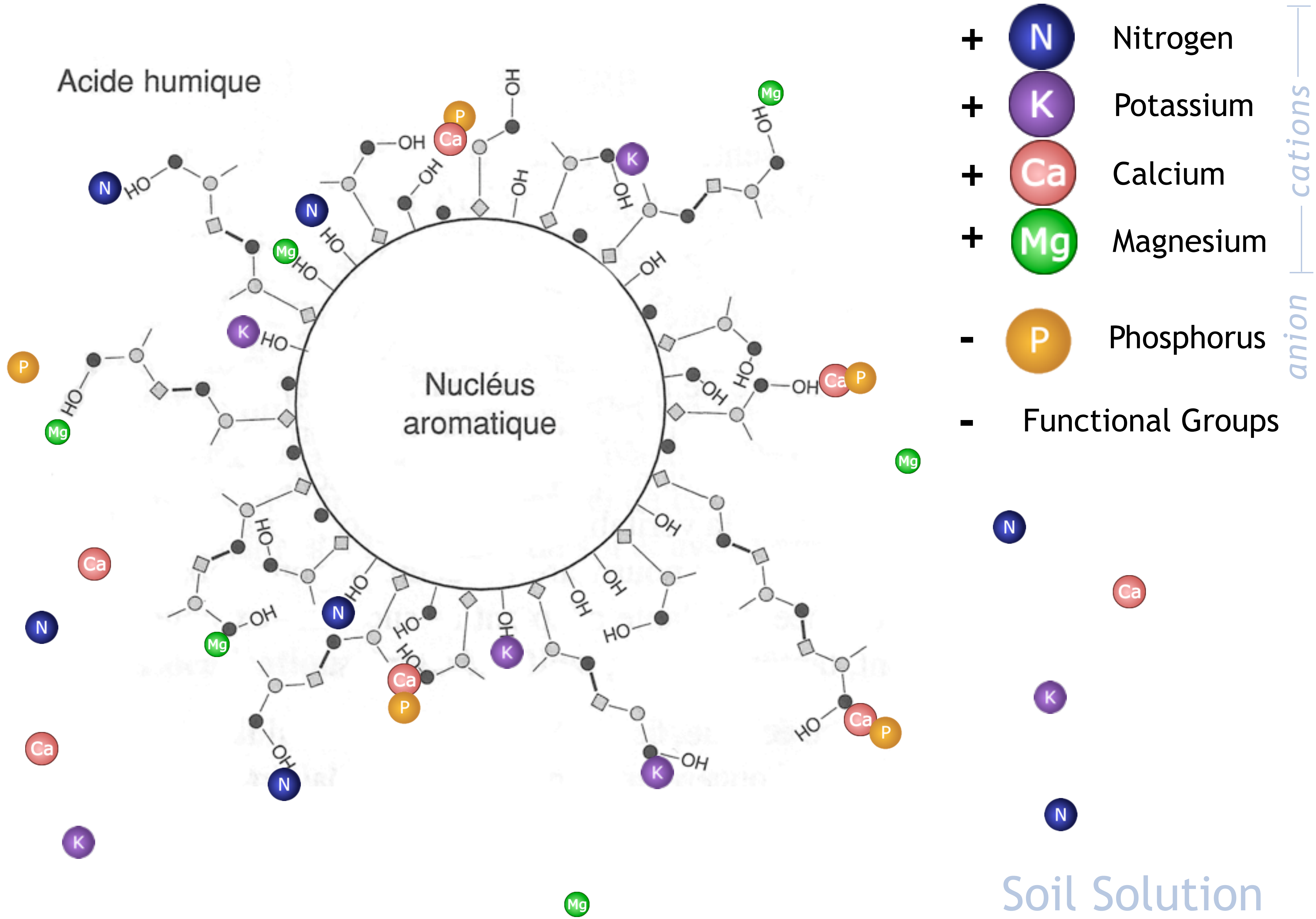

Acide humique
Nucléus
aromatique
HO
OH


+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
- P Phosphorus
- Functional Groups
cations
anion



Acide humique
Nucléus aromatique
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
cations
- P Phosphorus
anion
- Functional Groups
Soil Solution


Acide humique
Nucléus
aromatique
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
- P Phosphorus
- Functional Groups
cations
anion
Soil Solution


Acide humique
Nucléus aromatique
+ N Nitrogen
+ K Potassium
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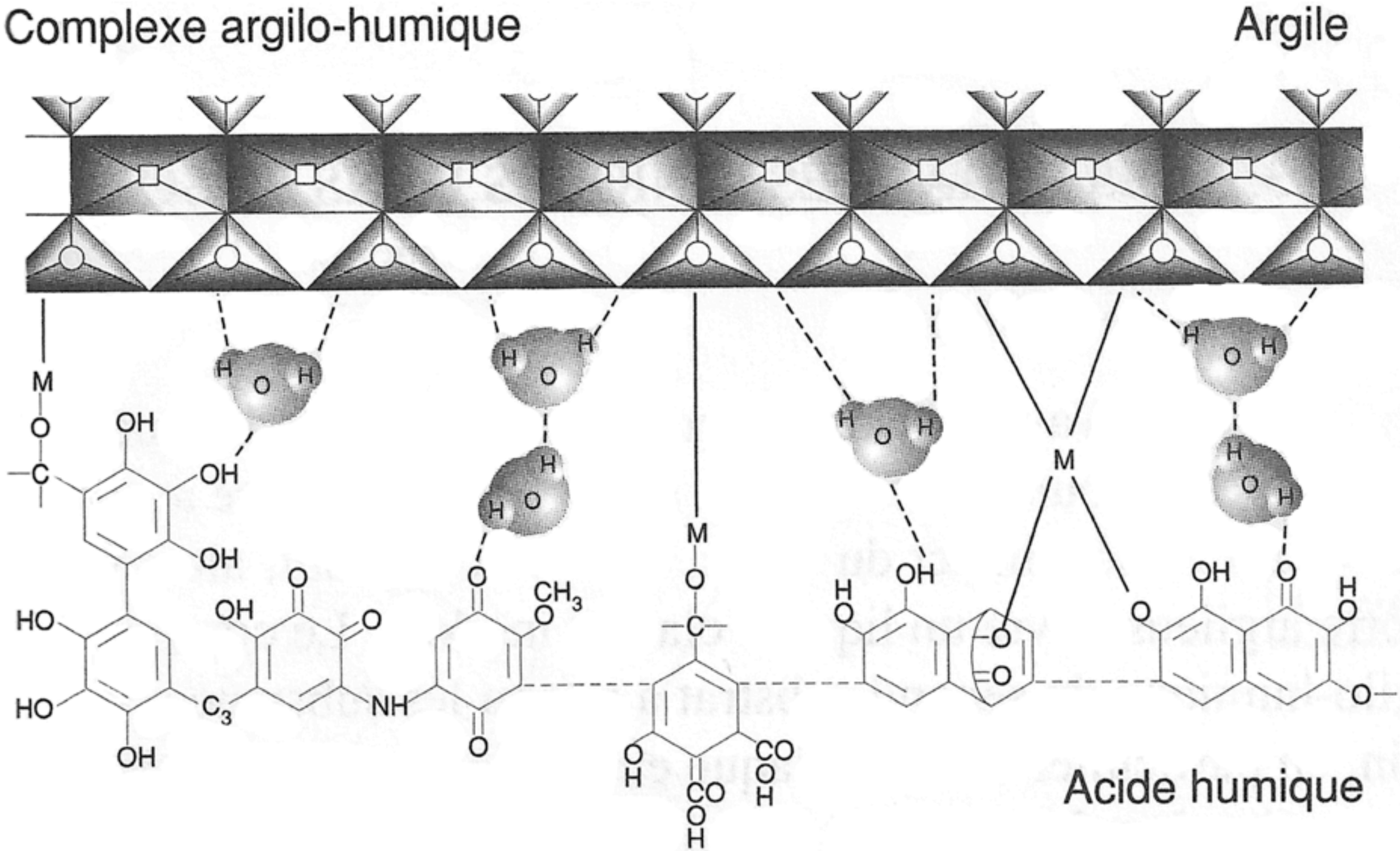
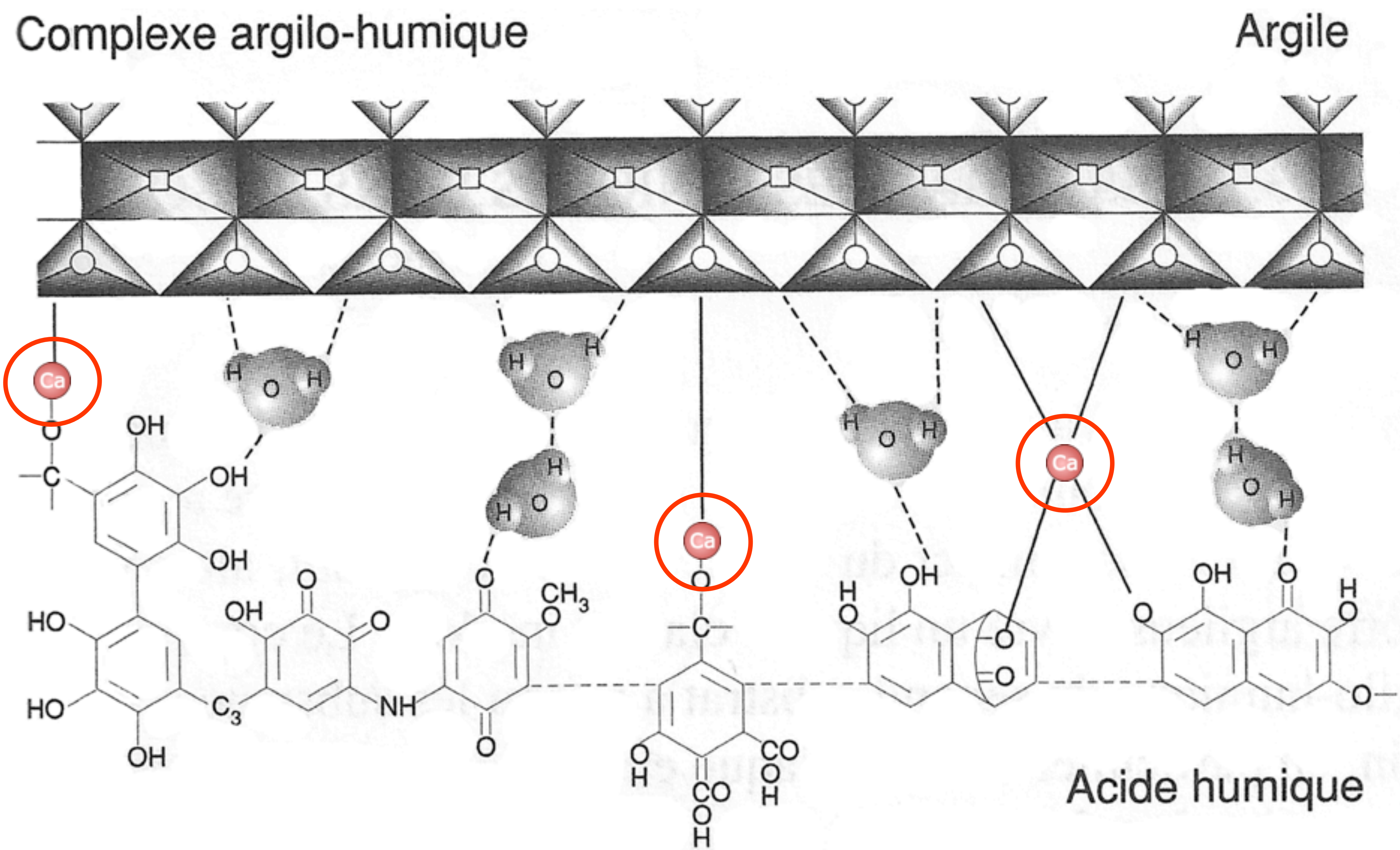
+ Mg Magnesium
- P Phosphorus
- Functional Groups
cations
anion
Soil Solution



Clay Humic Complex



Cation bridge, typically Ca++ or Fe++

Clay Humic Complex

Clay Humic Complex

Clay Humic Complex

- Important functions for soil fertility ...

Clay Humic Complex

* Important functions for soil fertility ...
* Promotes aggregation of soil particles, which helps retain water and allows root penetration

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- Helps protect humic acid from decomposition

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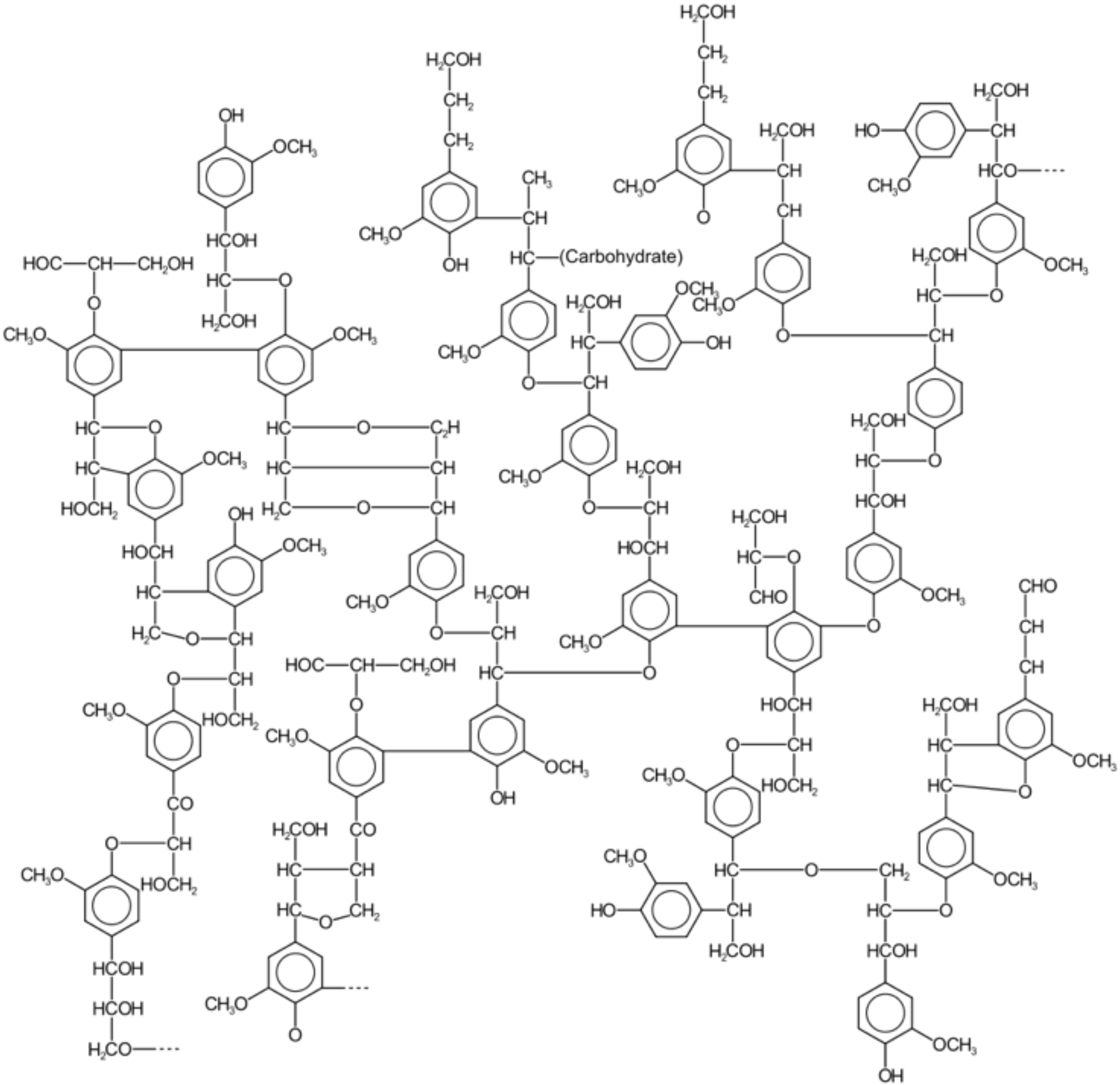
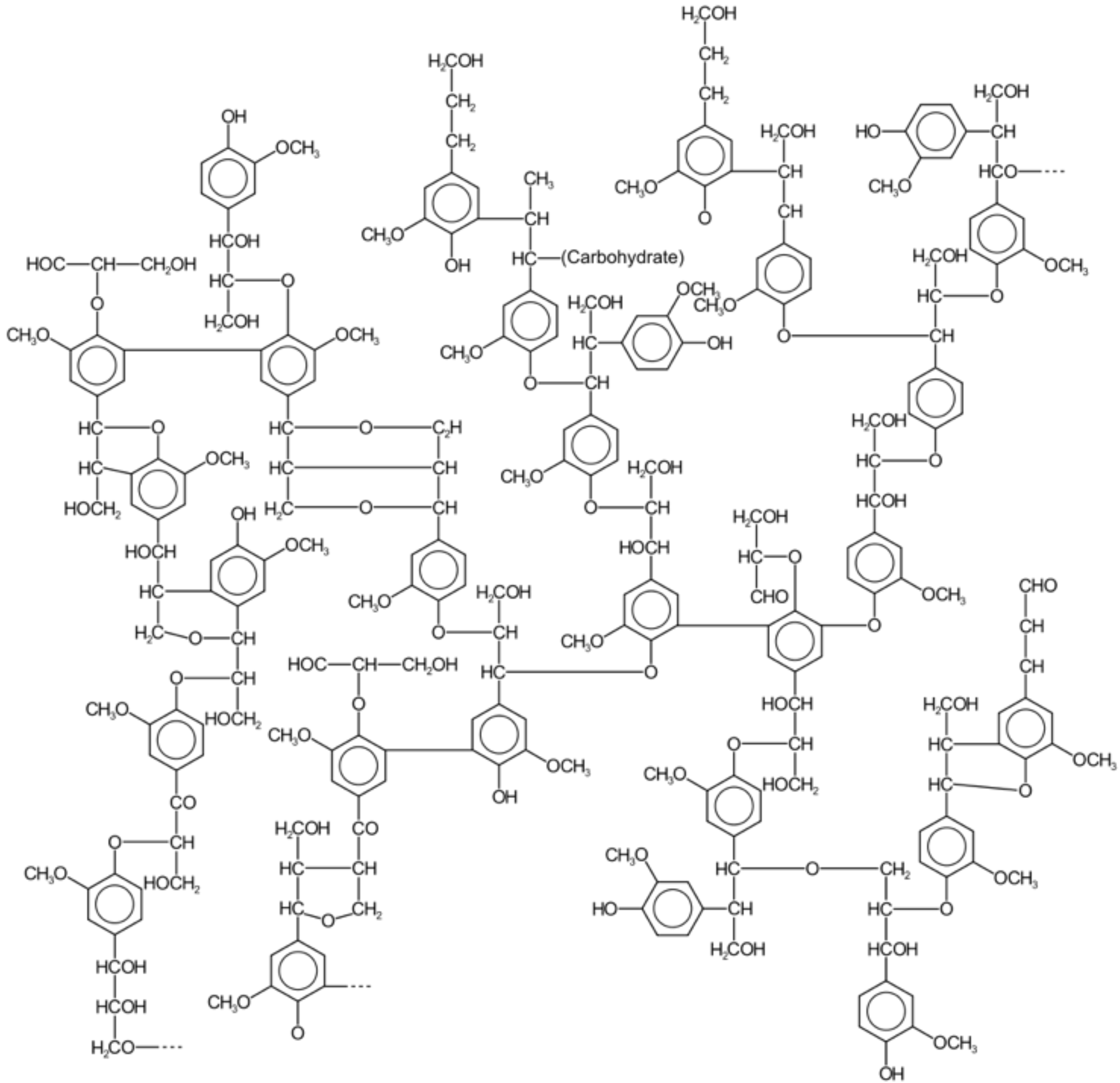
- Helps protect humic acid from decomposition
- Increases overall cation exchange capacity

Clay Humic Complex

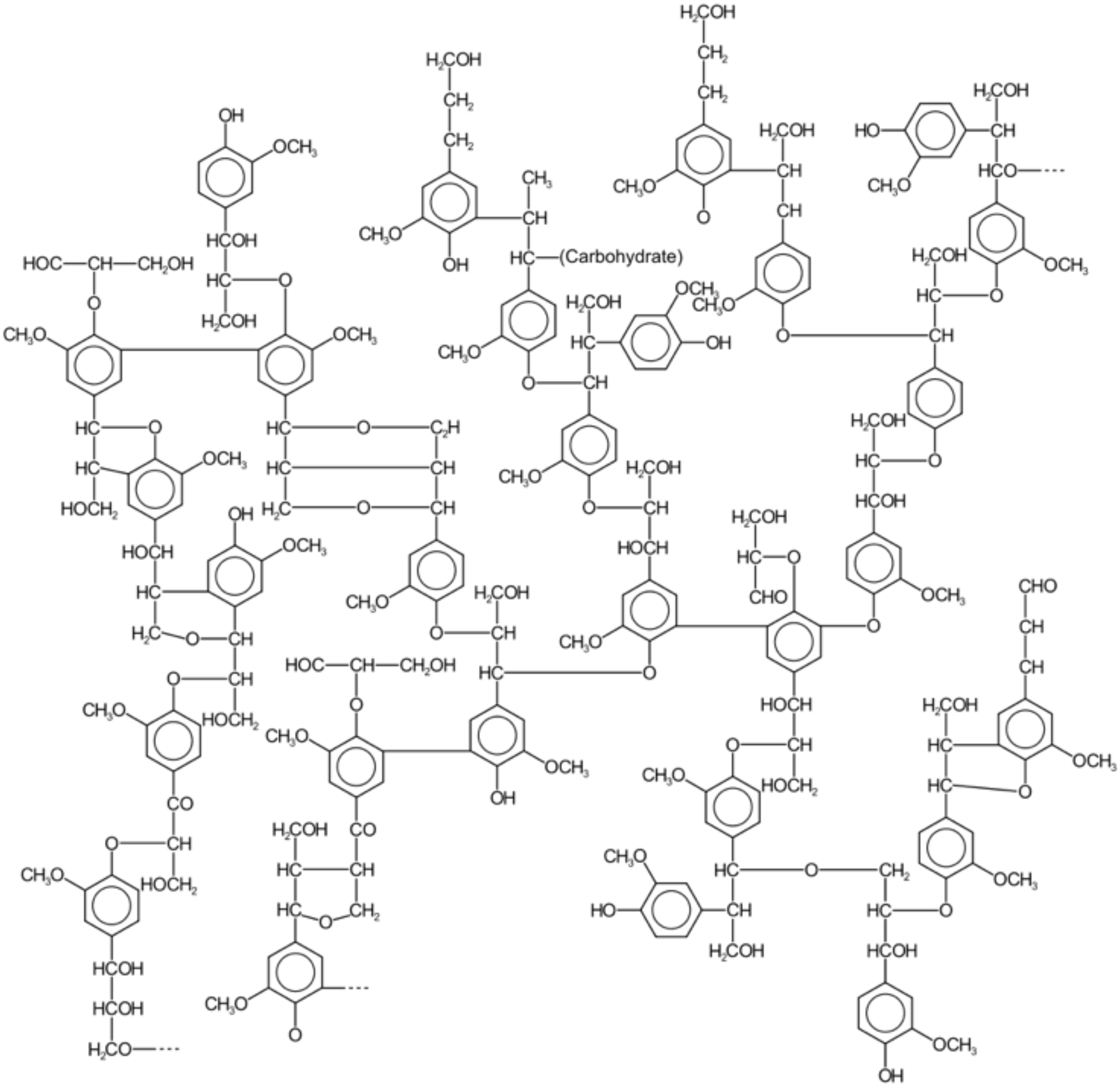
CarbonZero

- Important functions for soil fertility …
- Promotes aggregation of soil particles, which helps retain water and allows root penetration
- Helps protect humic acid from decomposition
- Increases overall cation exchange capacity
- Formation proceeds very slowly

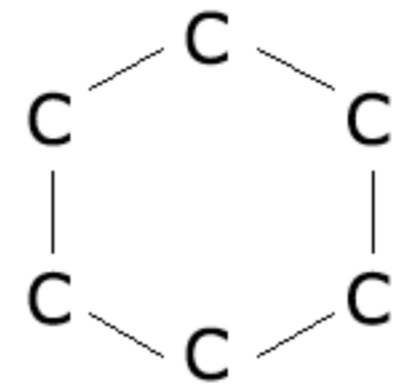

(Carbohydrate)



Molecular structure of lignin

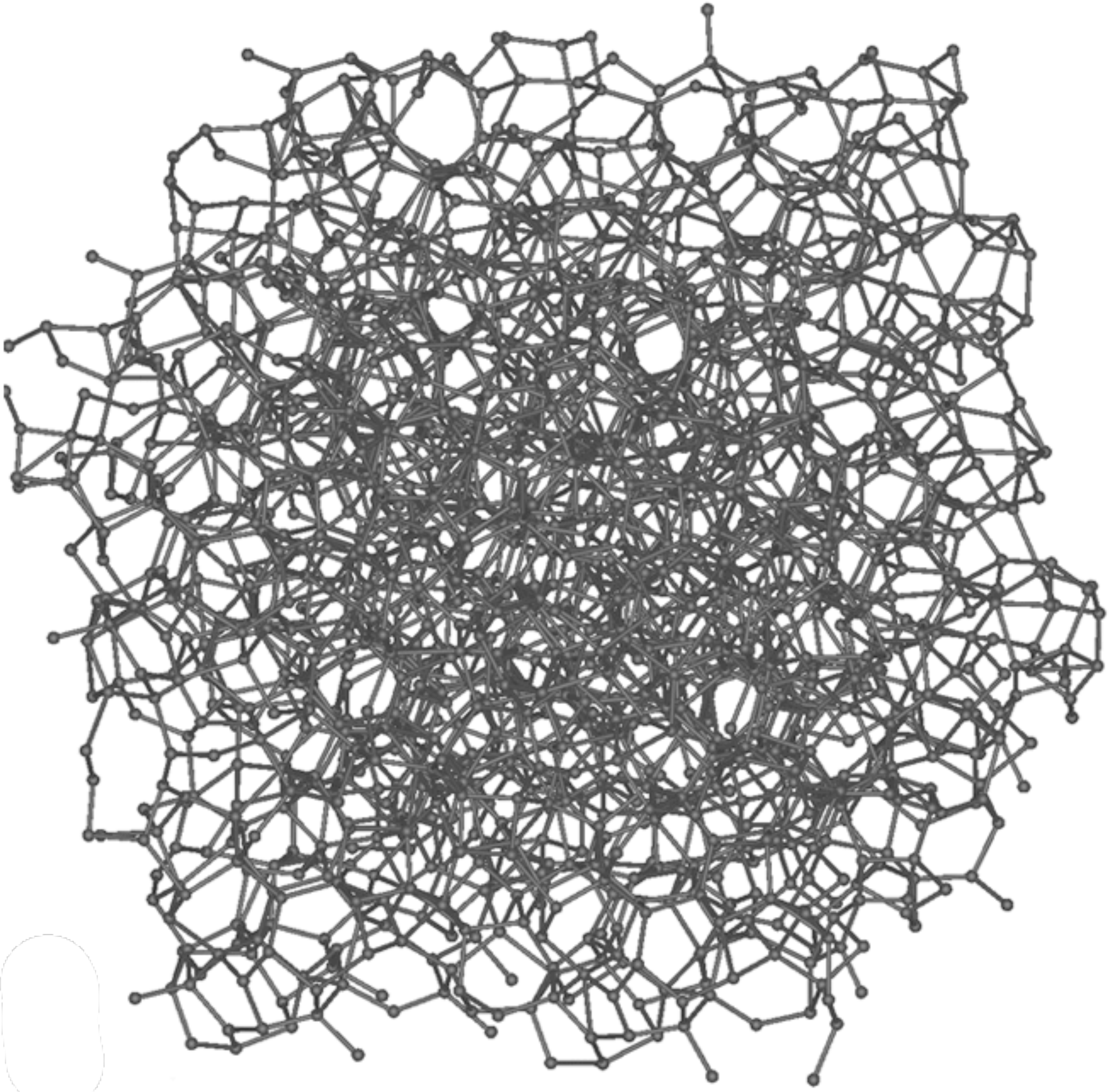


Molecular structure of lignin

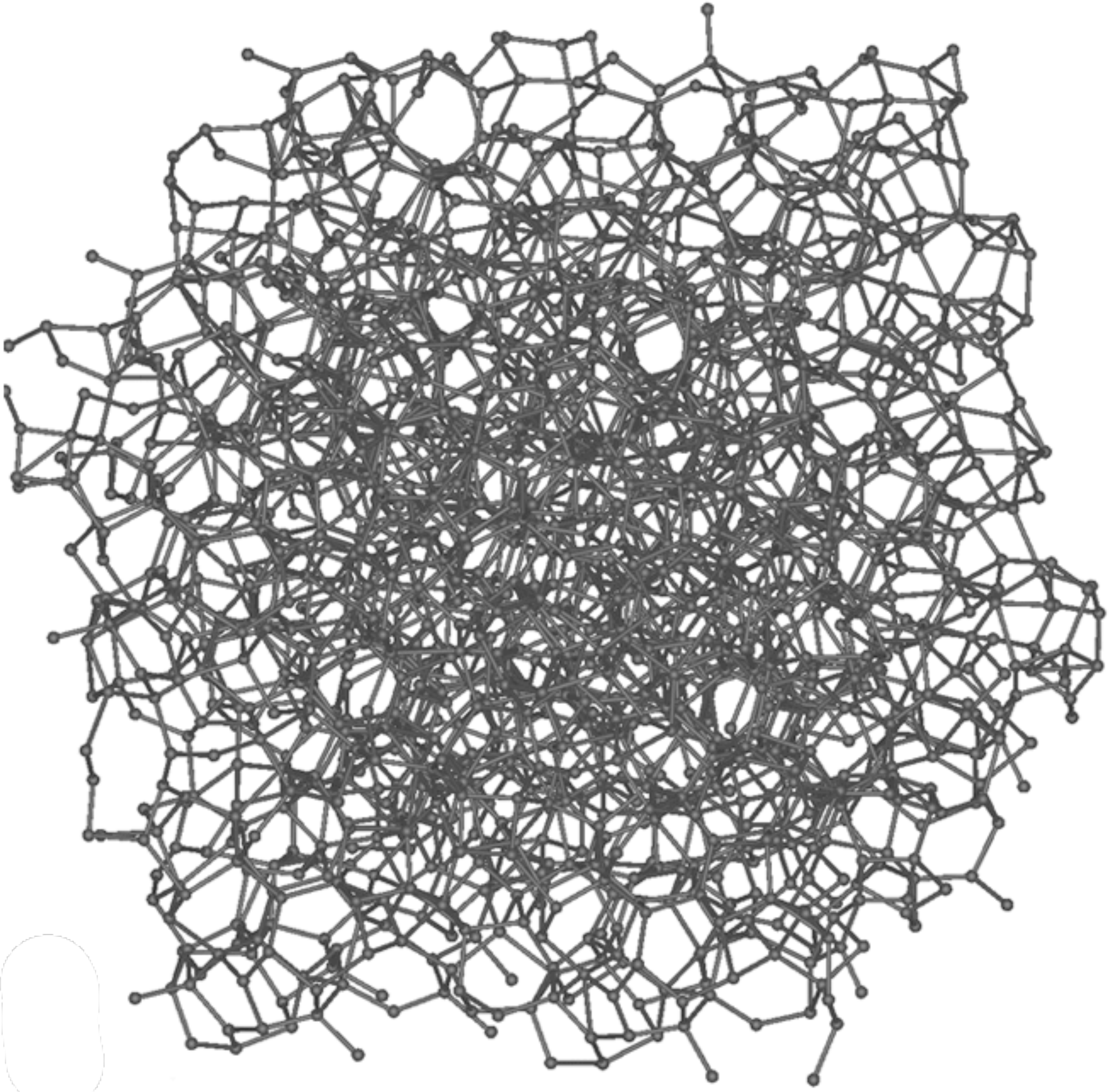


Aromatic rings

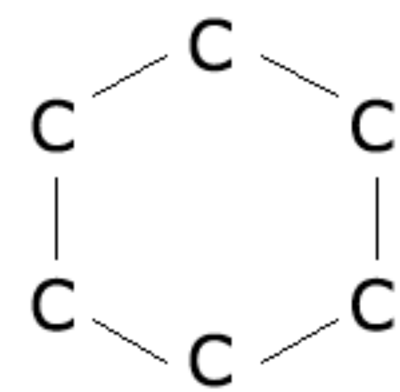
Basic building blocks of lignin



Molecular structure of char



Molecular structure of char



Aromatic rings

Basic building
blocks of char

Biochar-clay aggregates

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- Several biochar researchers noticed that biochars that significantly enhance fertility are often aggregated with clay particles

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Biochar-clay aggregates

Carbon Zero

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- Terra preta is both highly resistant to decomposition and very fertile

Biochar-clay aggregates

CarbonZero

- Several biochar researchers noticed that biochars that significantly enhance fertility are often aggregated with clay particles
- Terra preta in particular exhibits this characteristic
- Terra preta is both highly resistant to decomposition and very fertile
- Do biochar-clay aggregates function in a similar manner as humic acid-clay aggregates?

Enriched Biochar Formula

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- Low temperature char 320 - 450 C, fine grained

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- Mix with clay (smectite)

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Enriched Biochar Formula

CarbonZero

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- Mix with clay (smectite)
- Add dolomite (provides Ca++ cation bridge)
- Aerate the mixture to accelerate oxidation of char surfaces and thus formation of functional groups. Optionally add heat, ozone, hydrogen peroxide, acetic or citric acid to enhance oxidation rate.
- Add organic material to charge the biochar / clay complex with nutrients

Enriched Biochar Formula

CarbonZero

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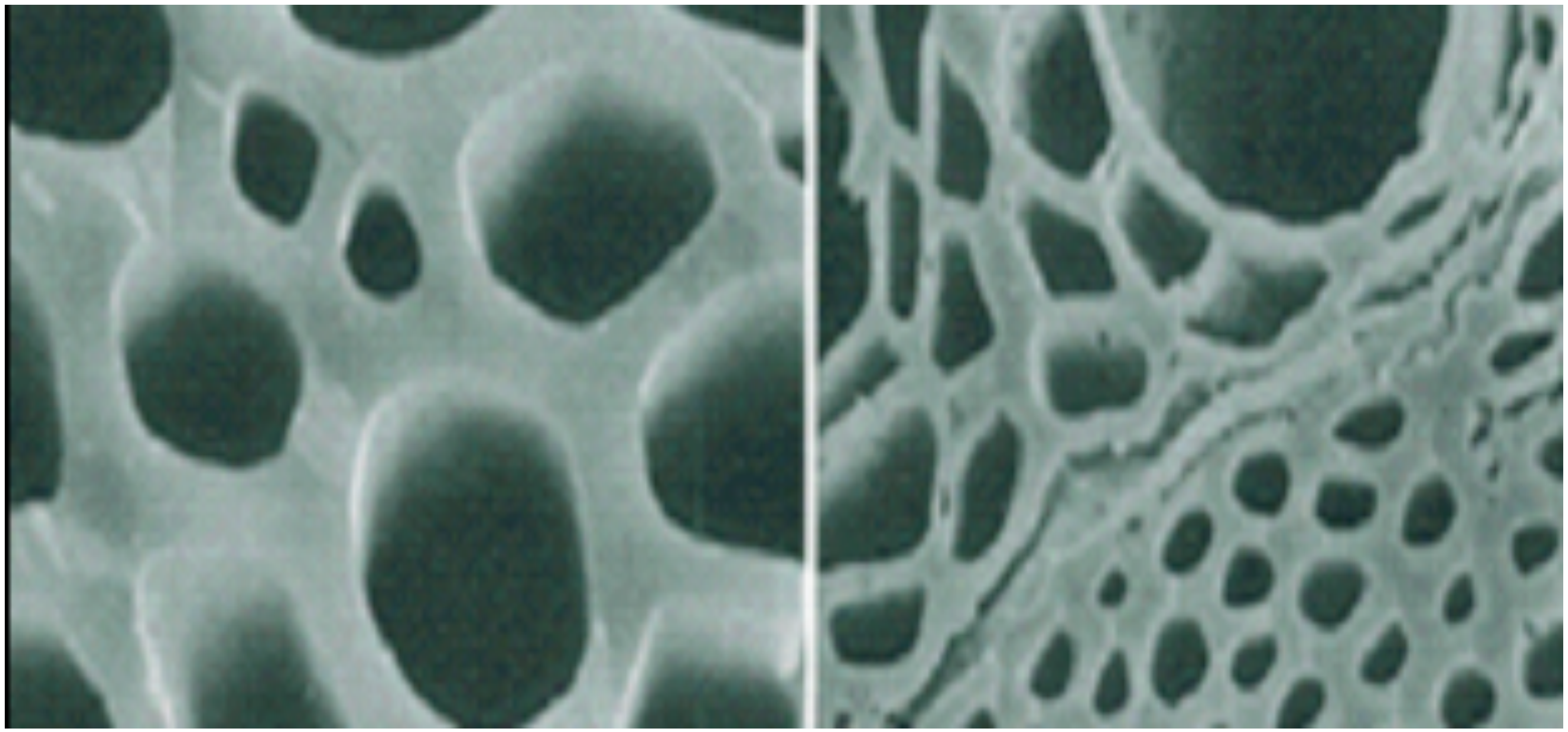
- Mix with clay (smectite)
- Add dolomite (provides Ca++ cation bridge)
- Aerate the mixture to accelerate oxidation of char surfaces and thus formation of functional groups. Optionally add heat, ozone, hydrogen peroxide, acetic or citric acid to enhance oxidation rate.
- Add organic material to charge the biochar / clay complex with nutrients
- Optionally inoculate with mycorrhizal fungi

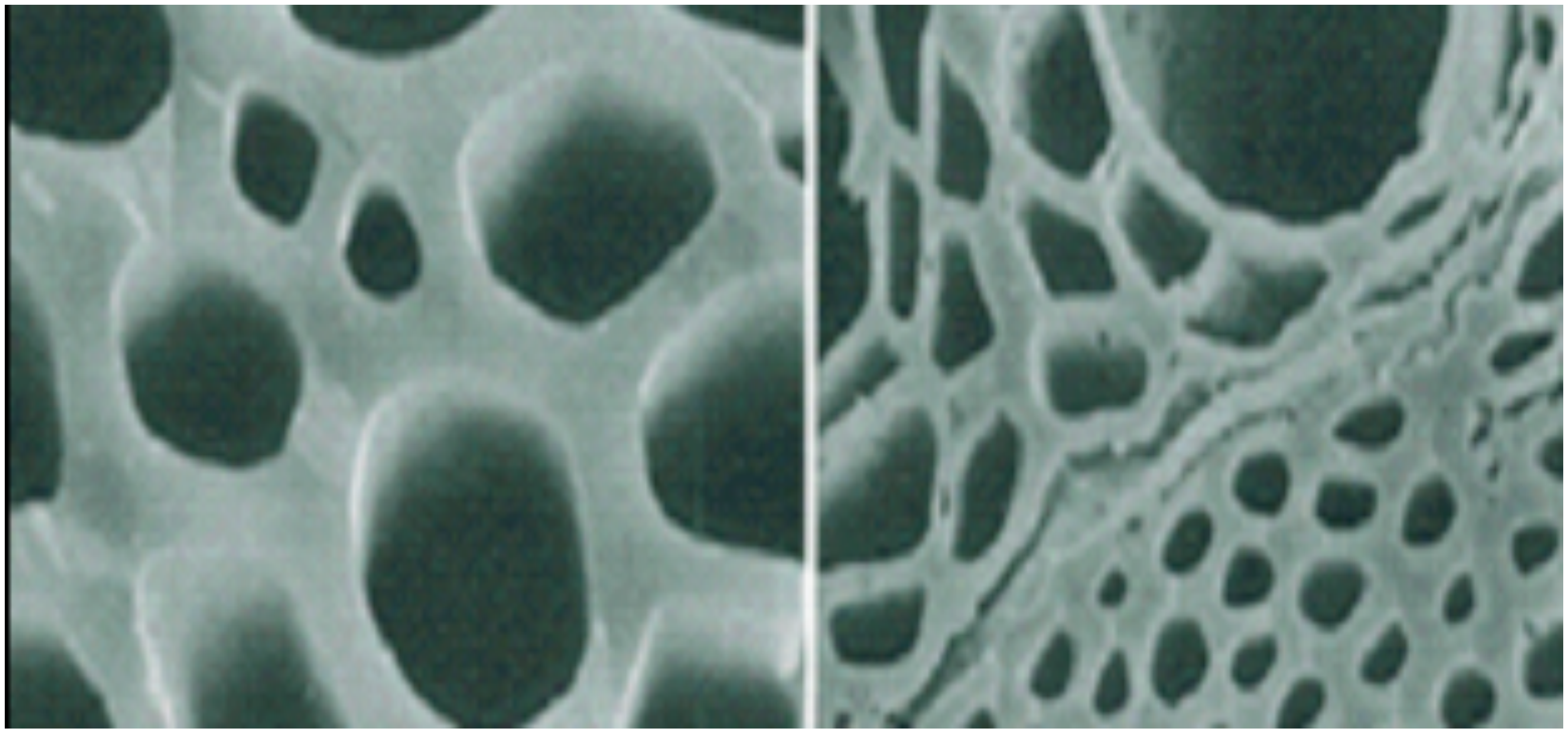
Biochar
How does it increase soil fertility?

Biochar
How does it increase soil fertility?



The fine porous structure geometrically multiplies surface area.
One gram of biochar can have the surface area of a football pitch!

Biochar
How does it increase soil fertility?

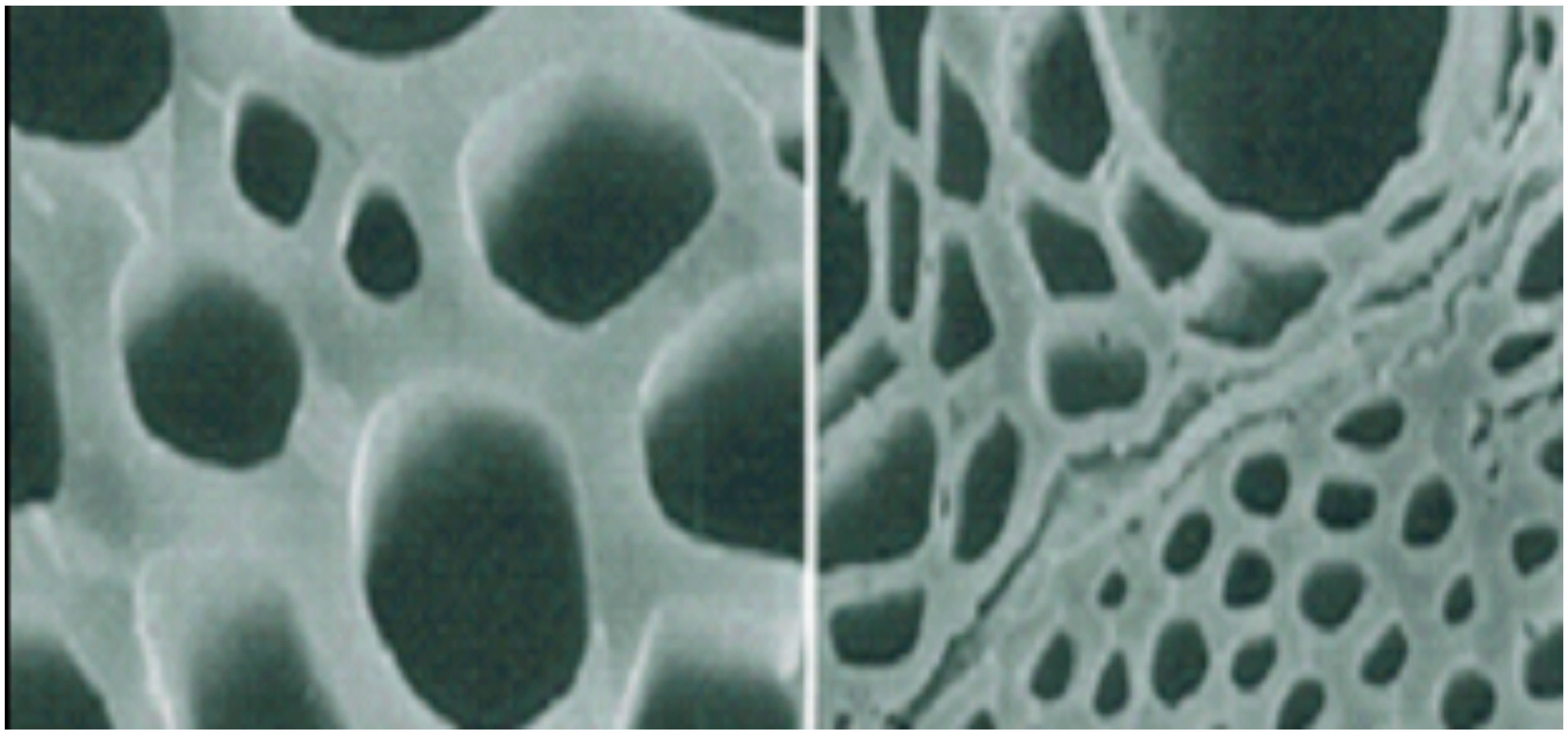


The fine porous structure geometrically multiplies surface area.
One gram of biochar can have the surface area of a football pitch!

+ Nitrogen
+ Potassium
+ Calcium
+ Magnesium

cations

Biochar
How does it increase soil fertility?

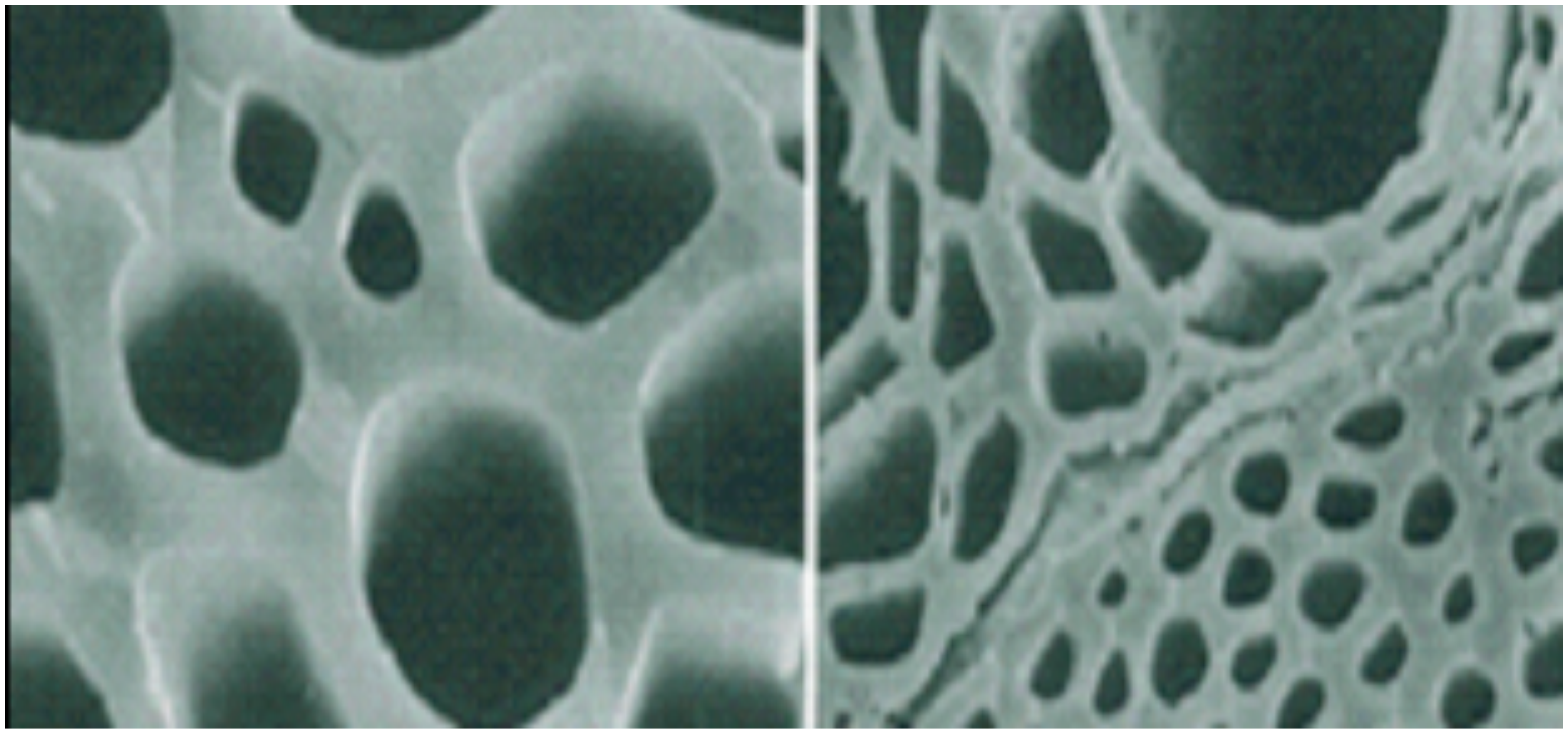


The fine porous structure geometrically multiplies surface area.
One gram of biochar can have the surface area of a football pitch!

- \+ Nitrogen
- \+ Potassium
- \+ Calcium
- \+ Magnesium
- \- Biochar

cations

Biochar
How does it increase soil fertility?



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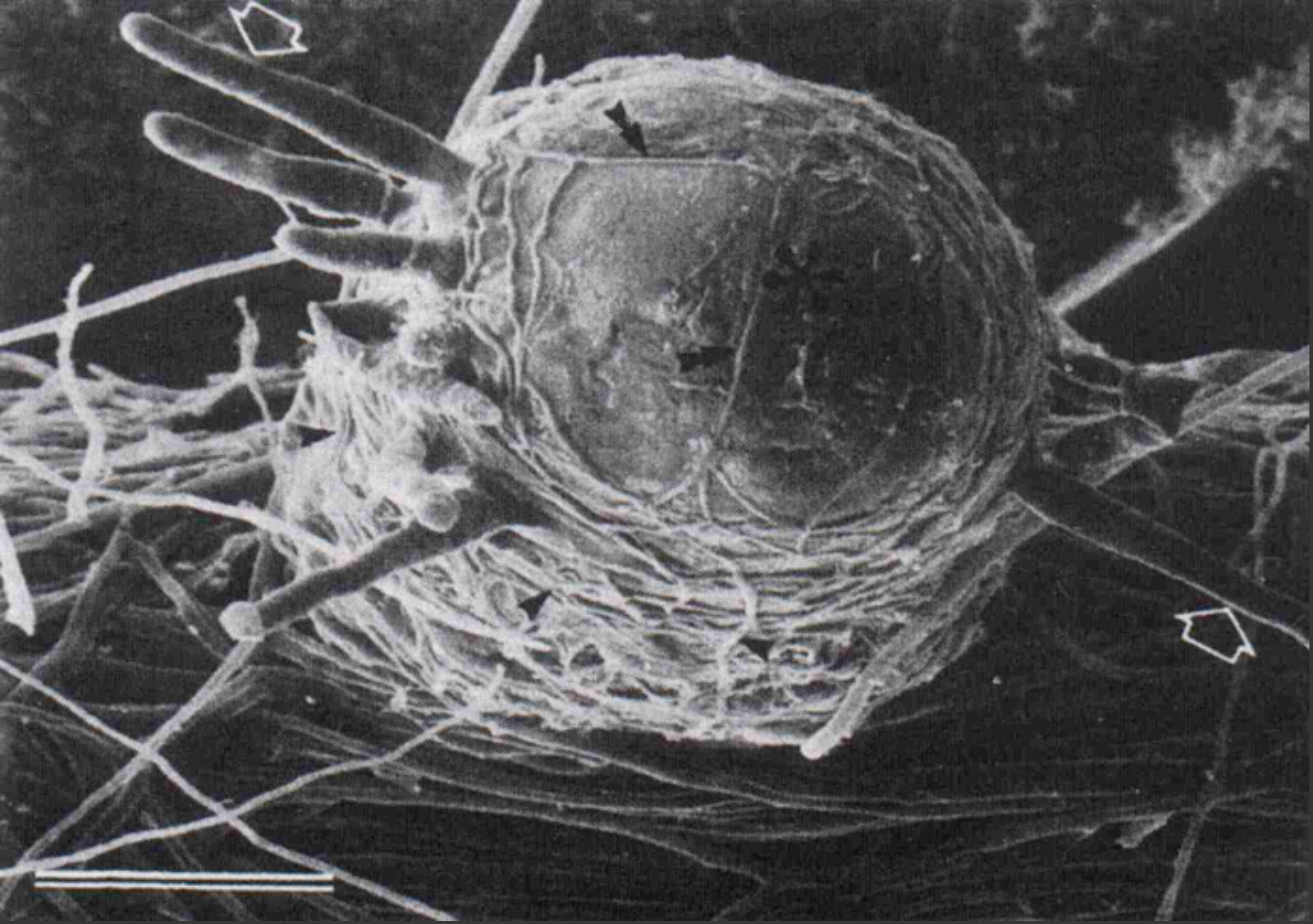
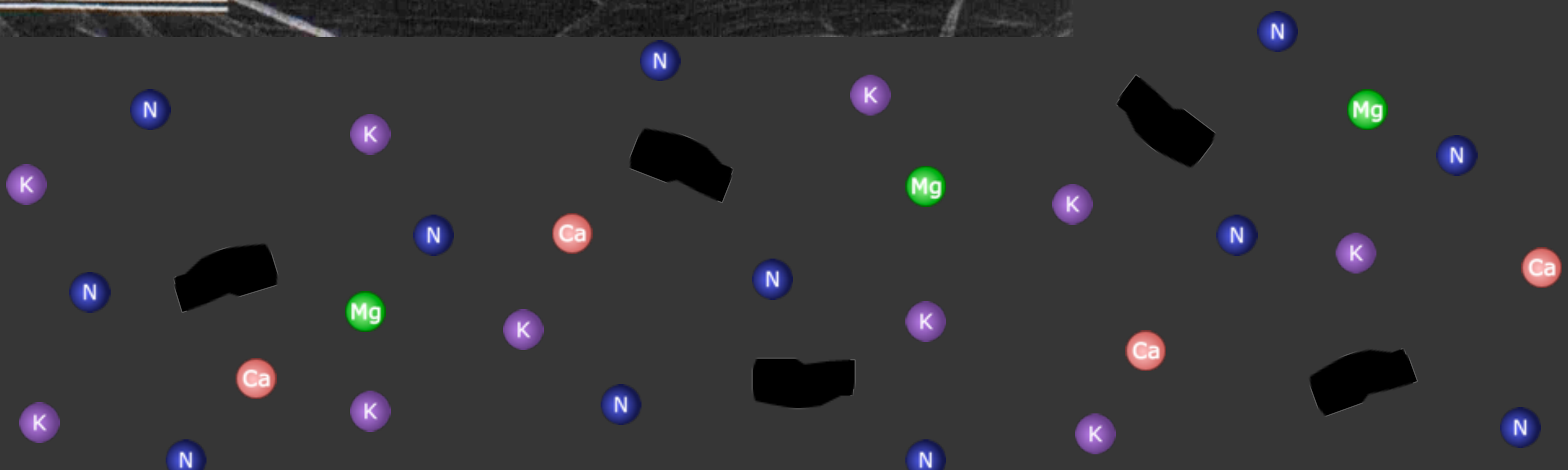
One gram of biochar can have the surface area of a football pitch!

- \+ Nitrogen
- \+ Potassium
- \+ Calcium
- \+ Magnesium
- \- Biochar

cations

The electrochemical attraction between biochar and cations retains these nutrients in the root zone, keeping them available for the plant when needed. The comparatively vast surface area amplifies cation storage capacity.





N
N
K
N
Mg
K
N
K
Mg
K
N
Ca
N
K
Ca
N
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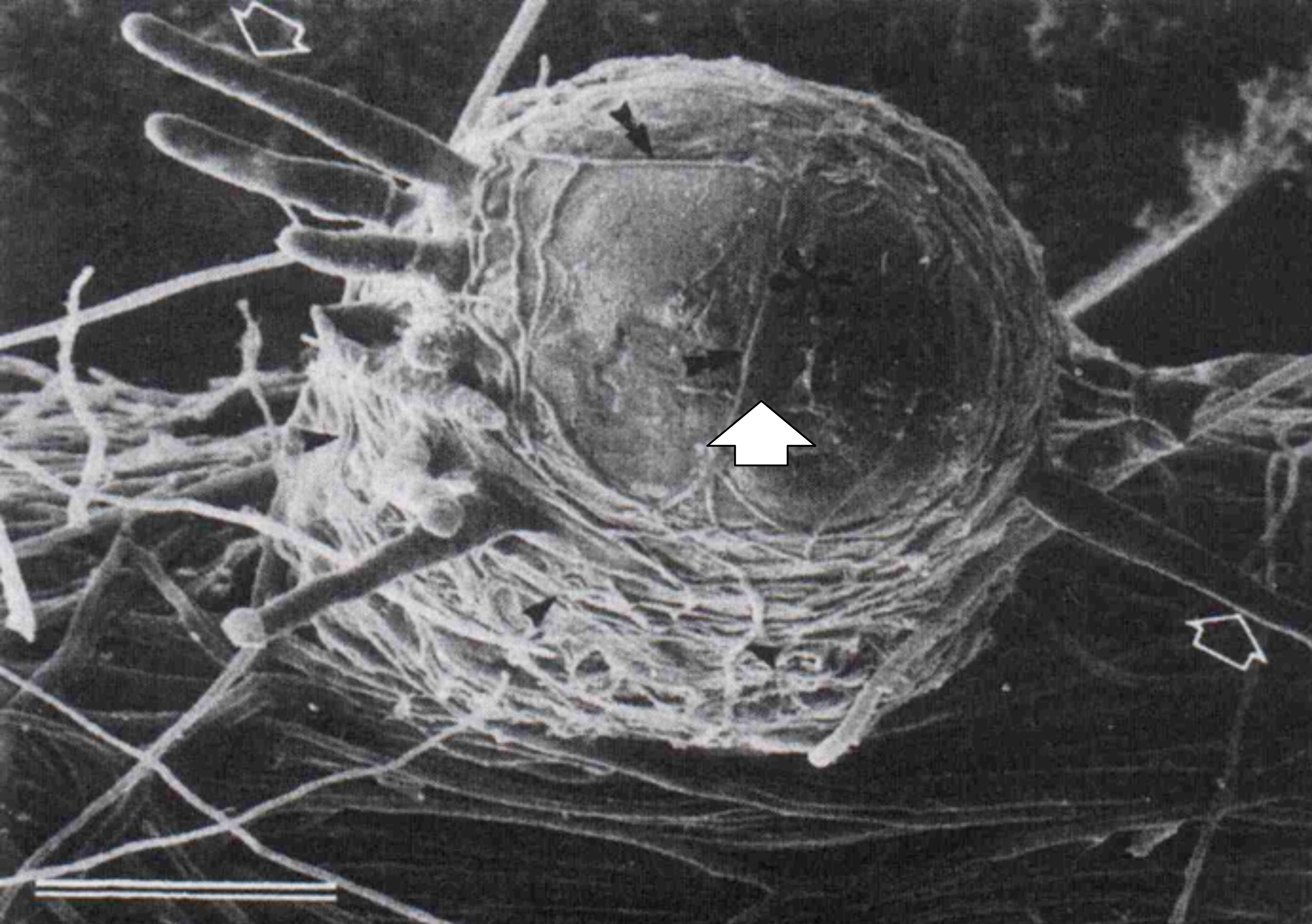
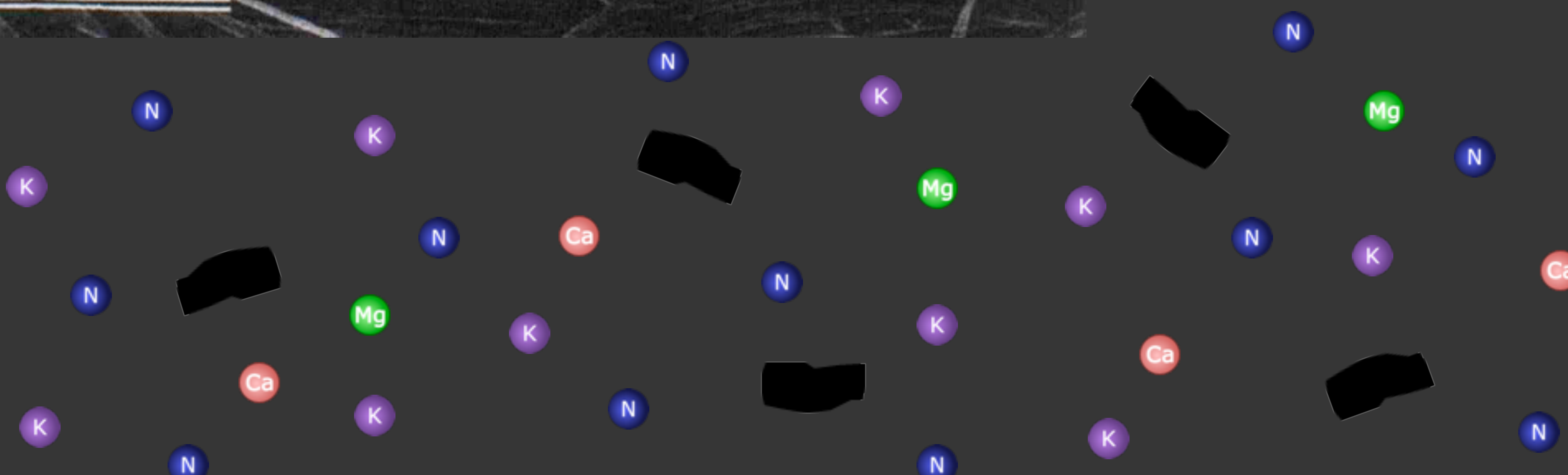
Mg
K
K
Ca
Ca
N
K
K
N
K
N
N




N
N
K
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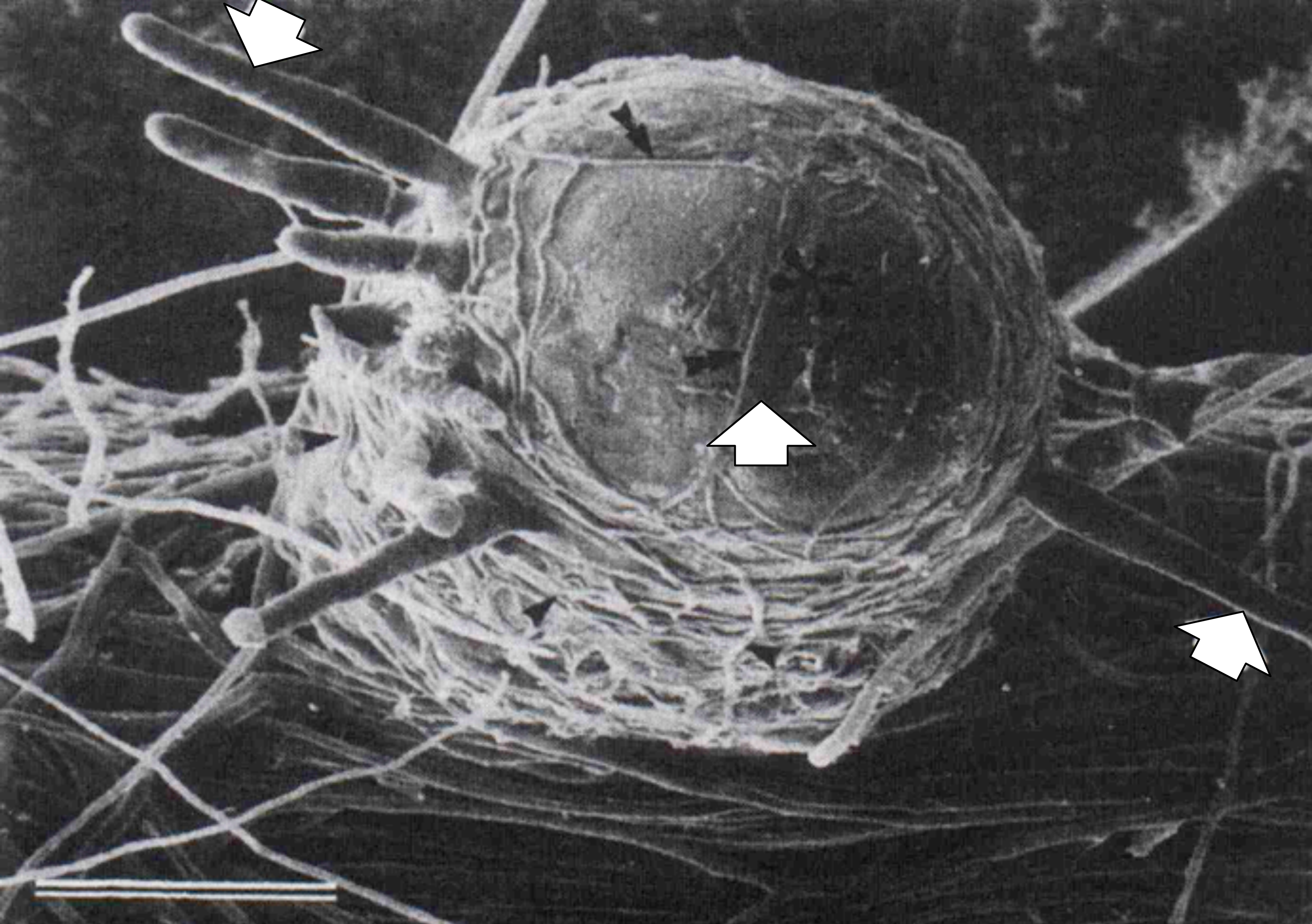

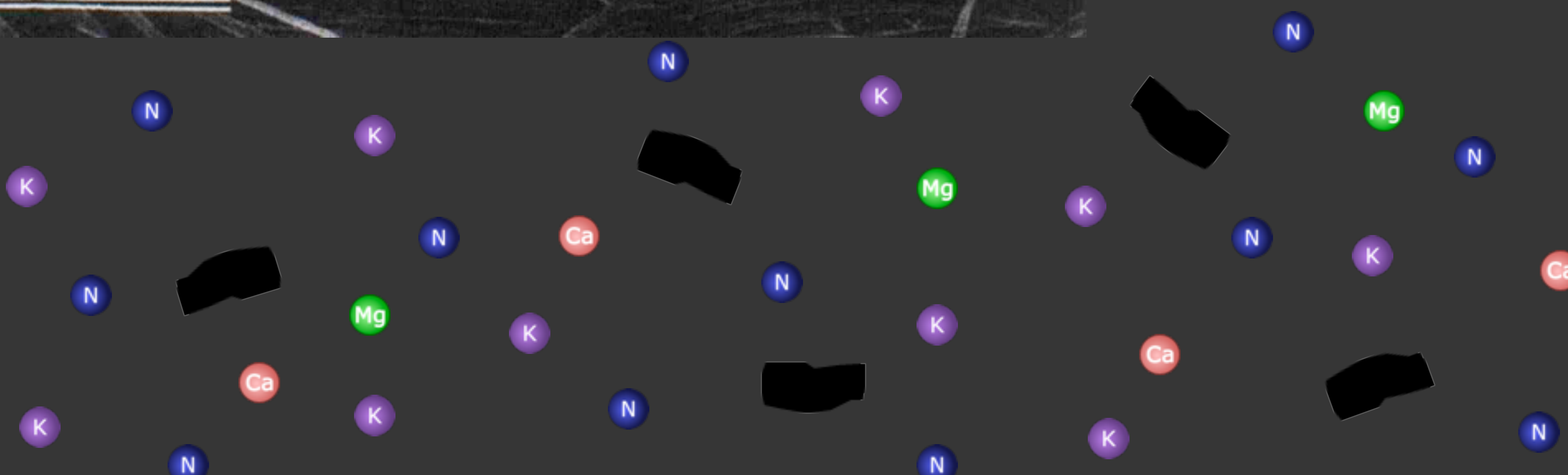
N
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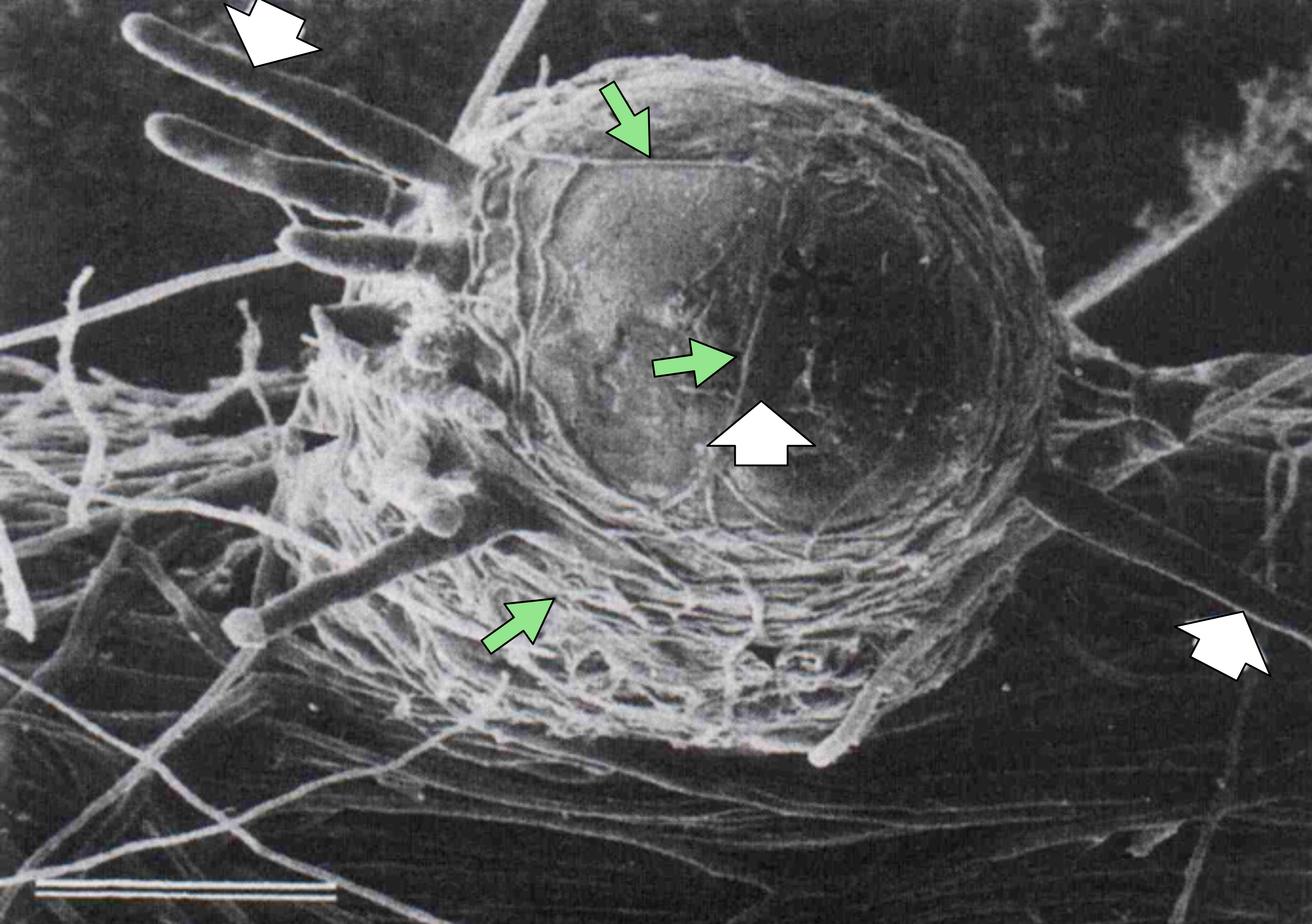
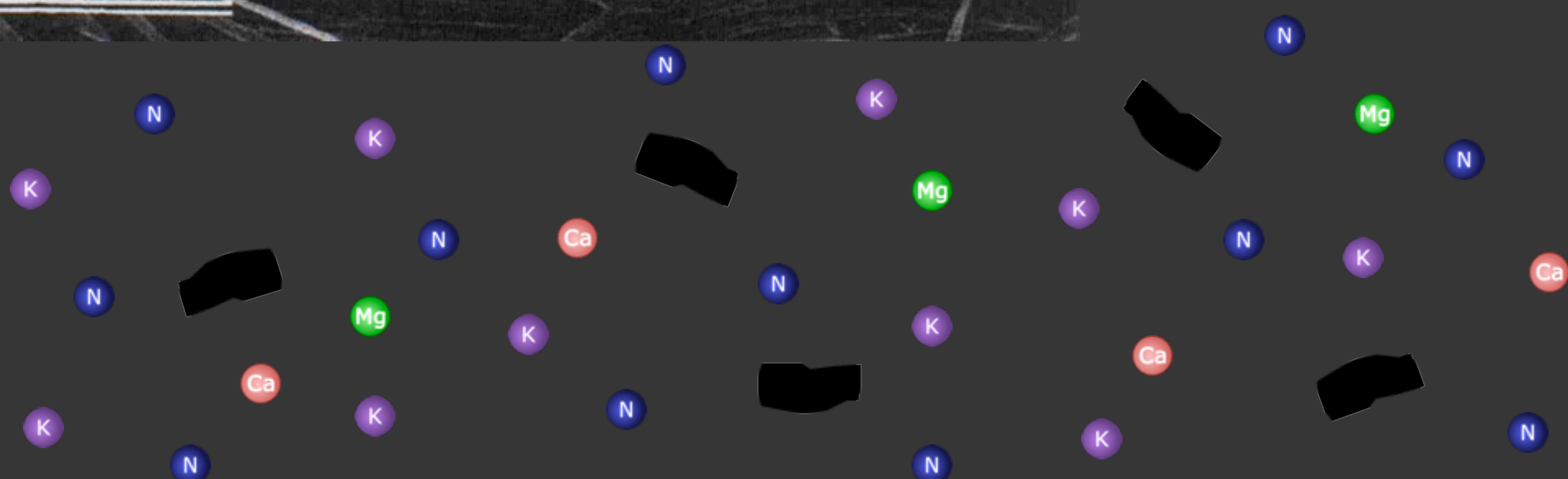
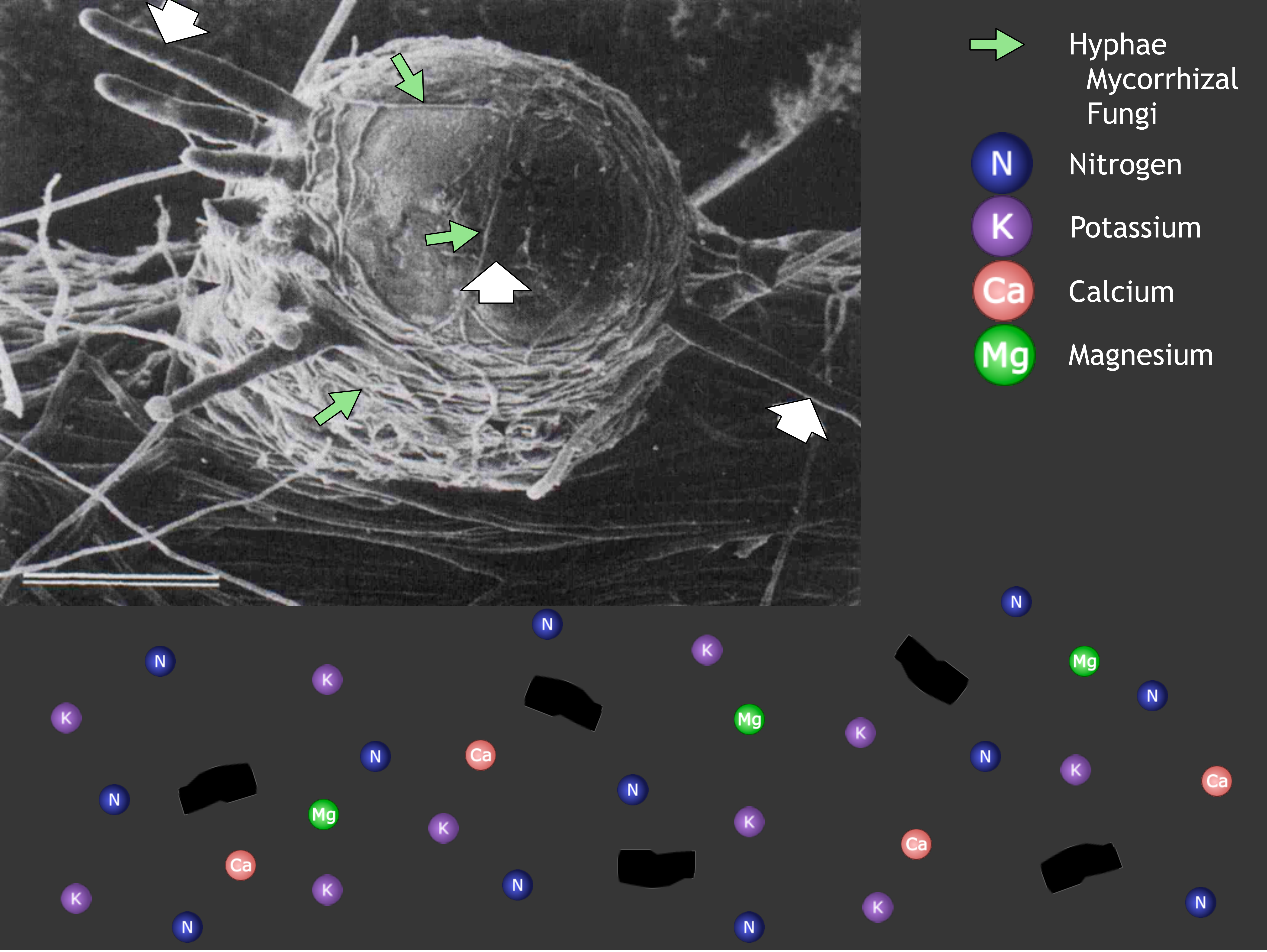
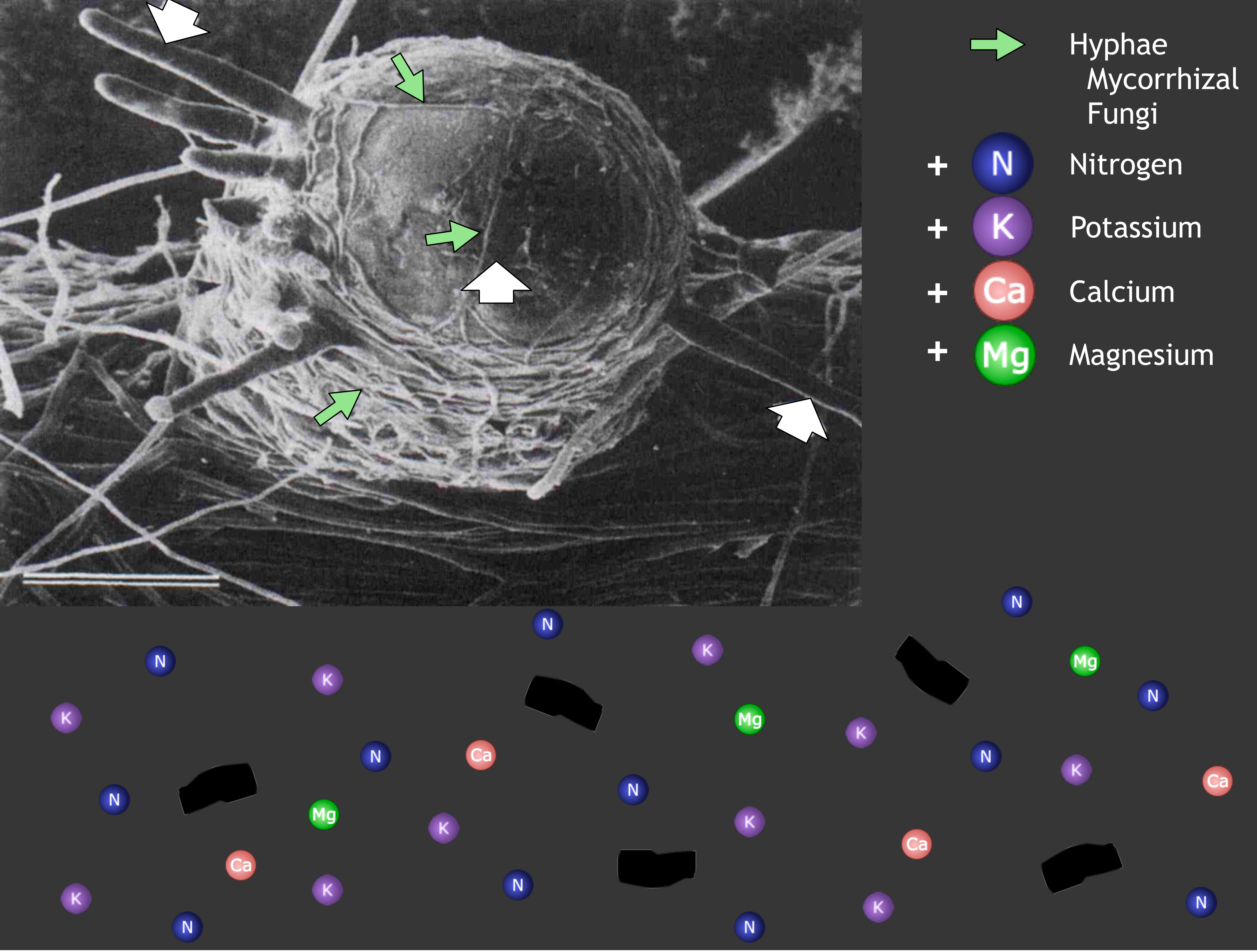
K
N
N

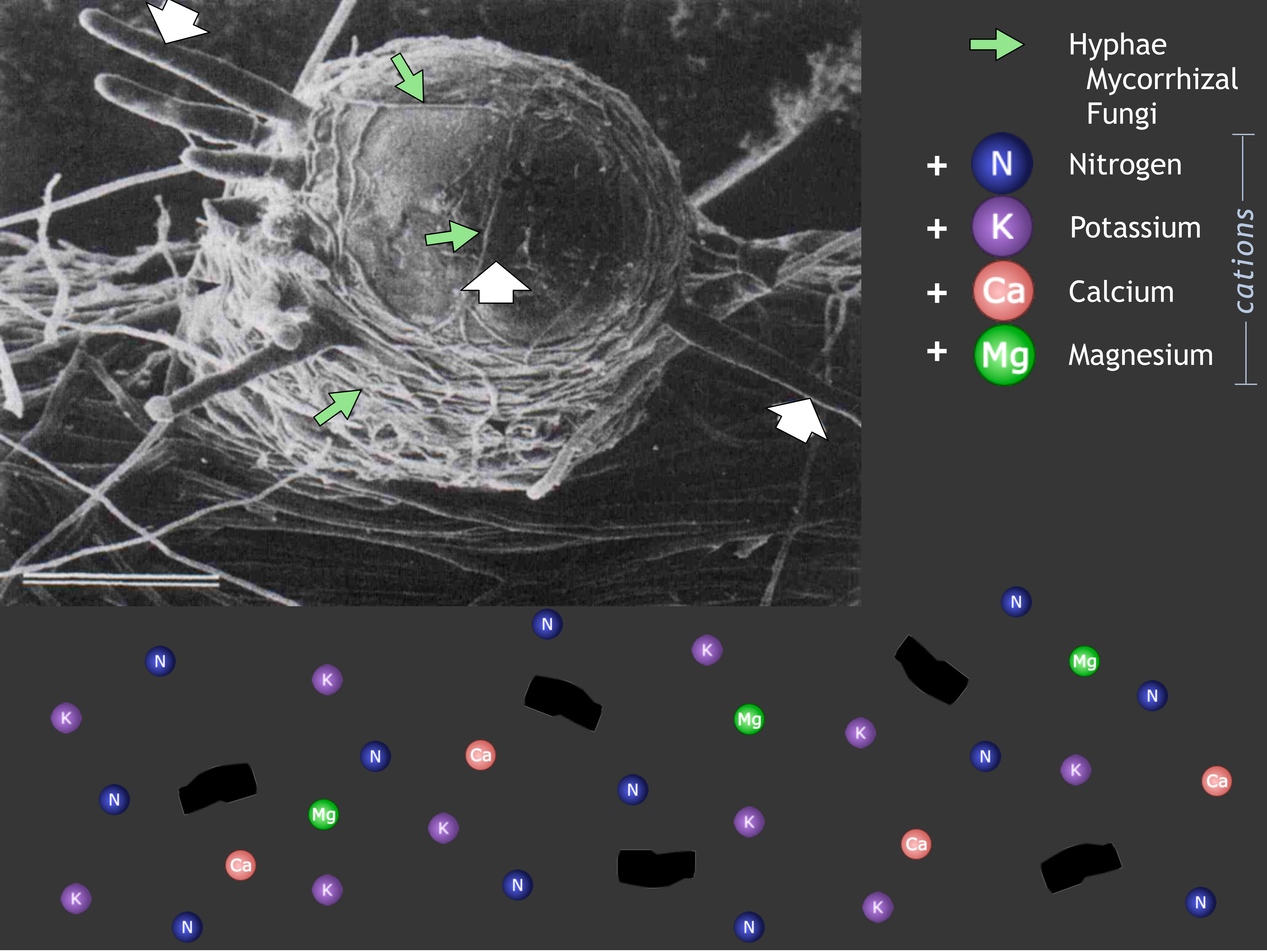


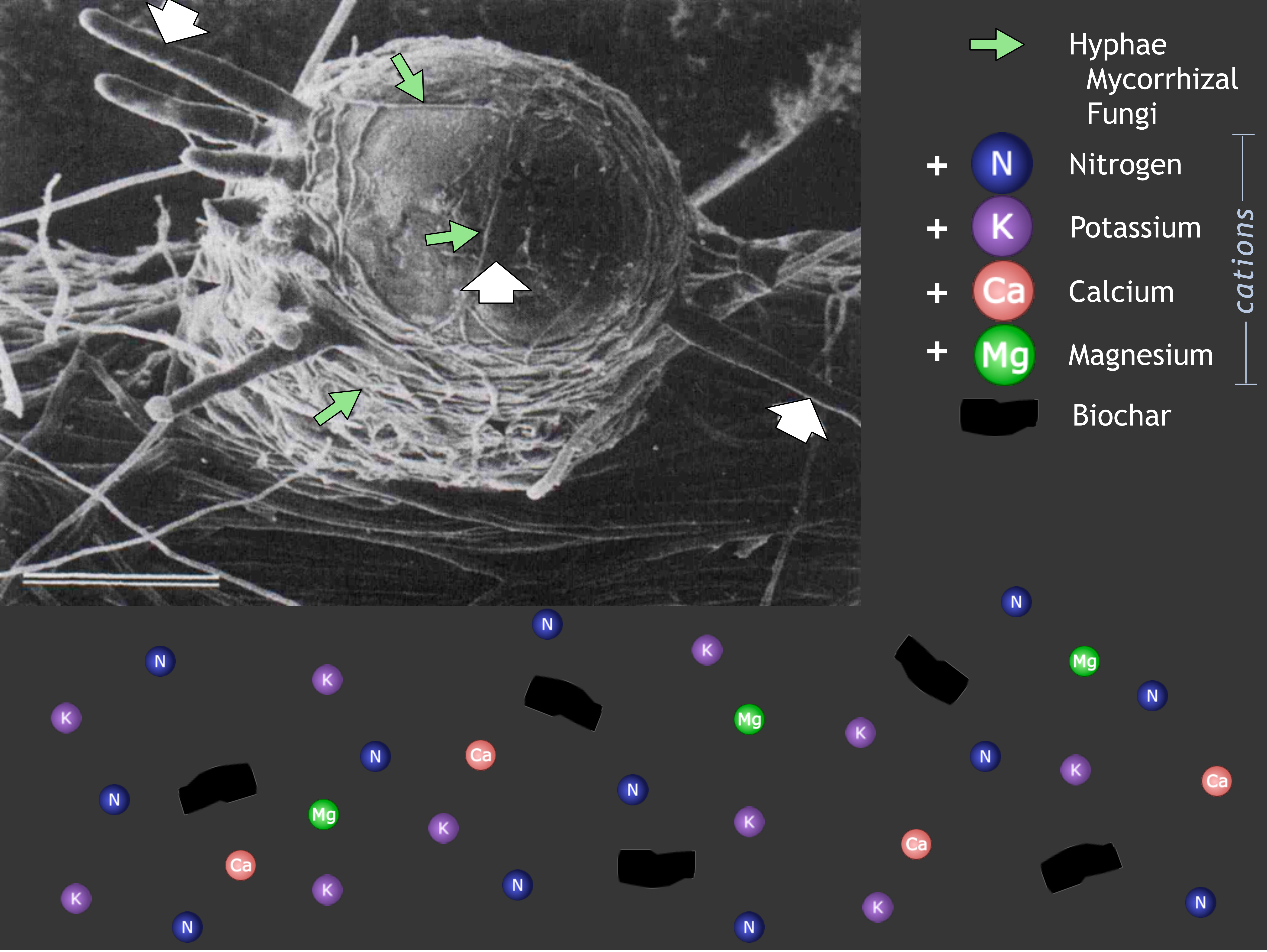
Hyphae
Mycorrhizal
Fungi

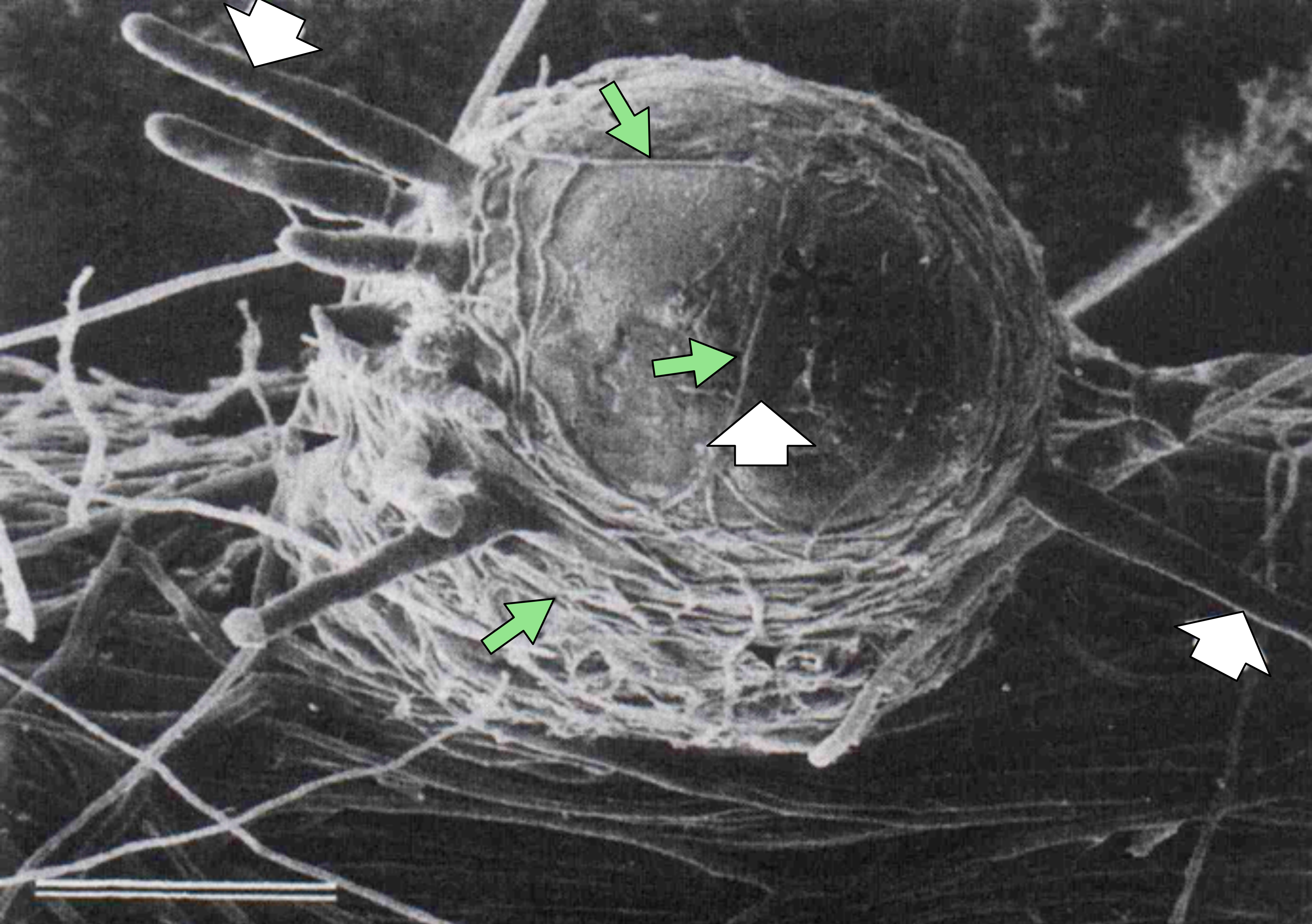



Hyphae Mycorrhizal Fungi
N Nitrogen
K Potassium
Ca Calcium
Mg Magnesium


Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium


Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
cations


Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
Biochar
cations



Hyphae Mycorrhizal Fungi

+ N Nitrogen

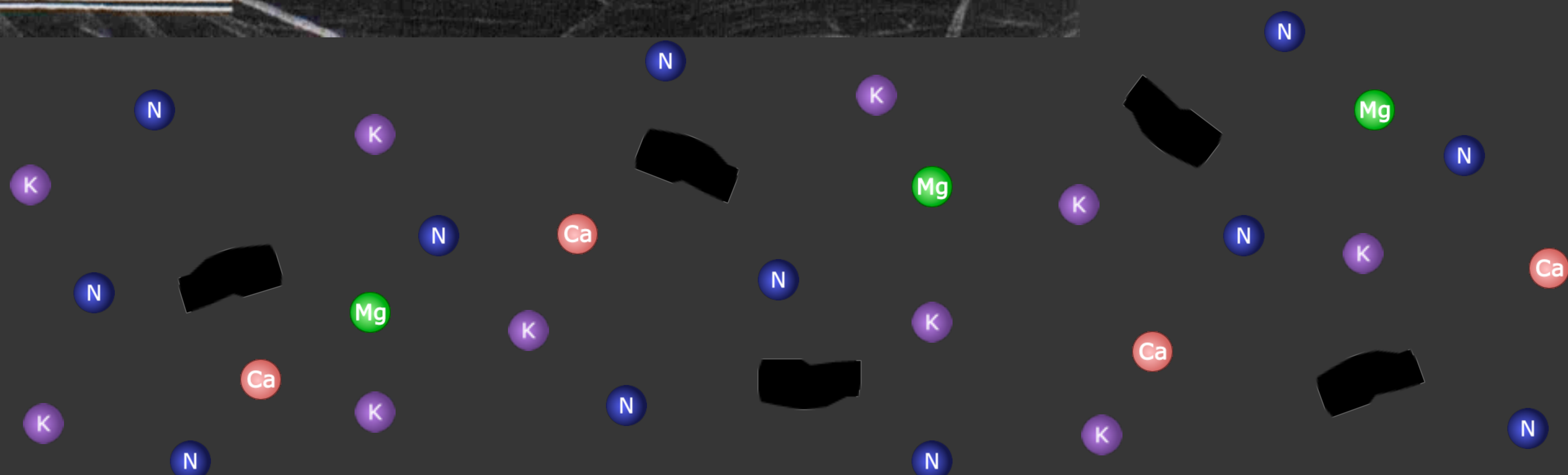
+ K Potassium

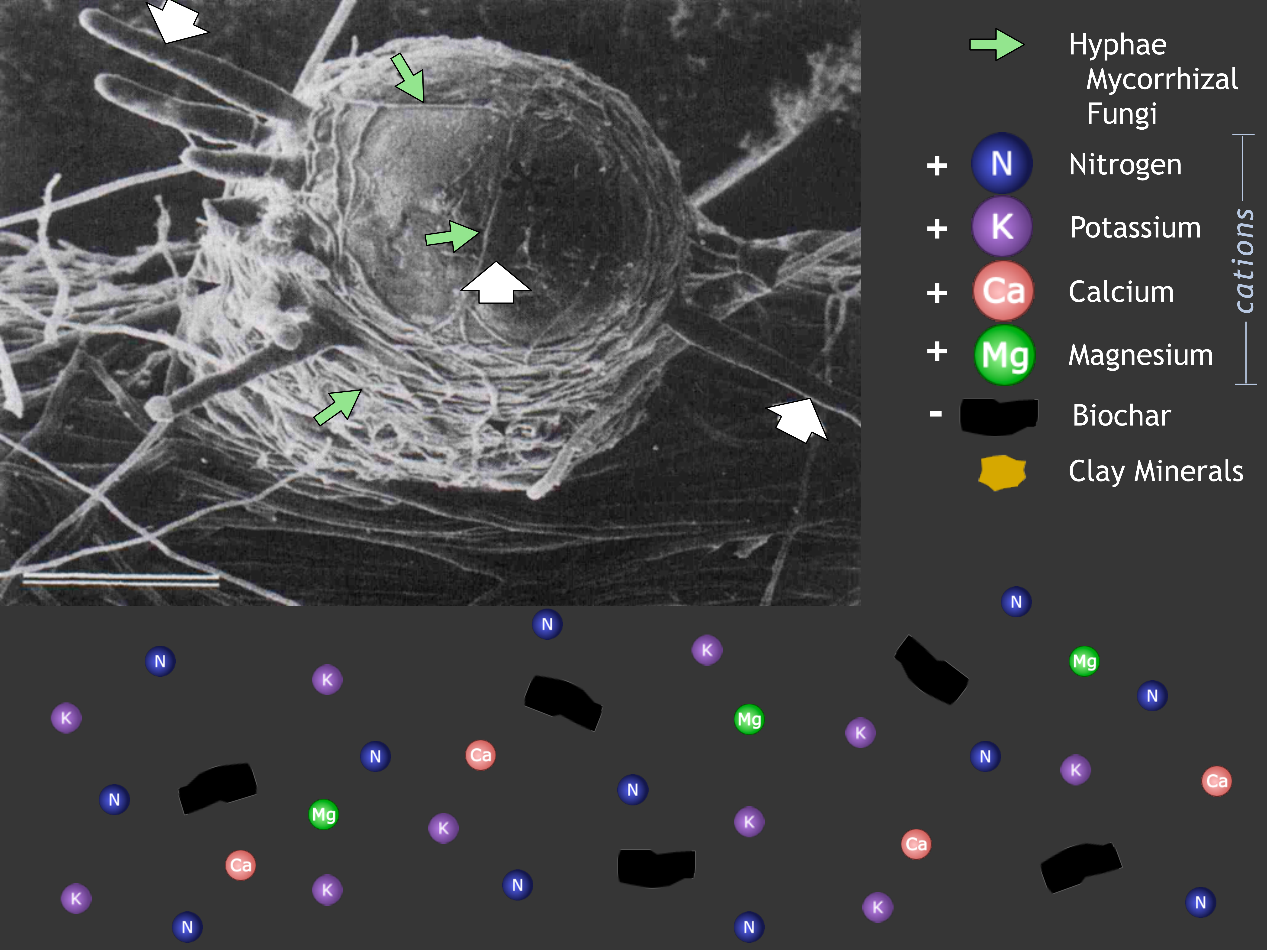
+ Ca Calcium

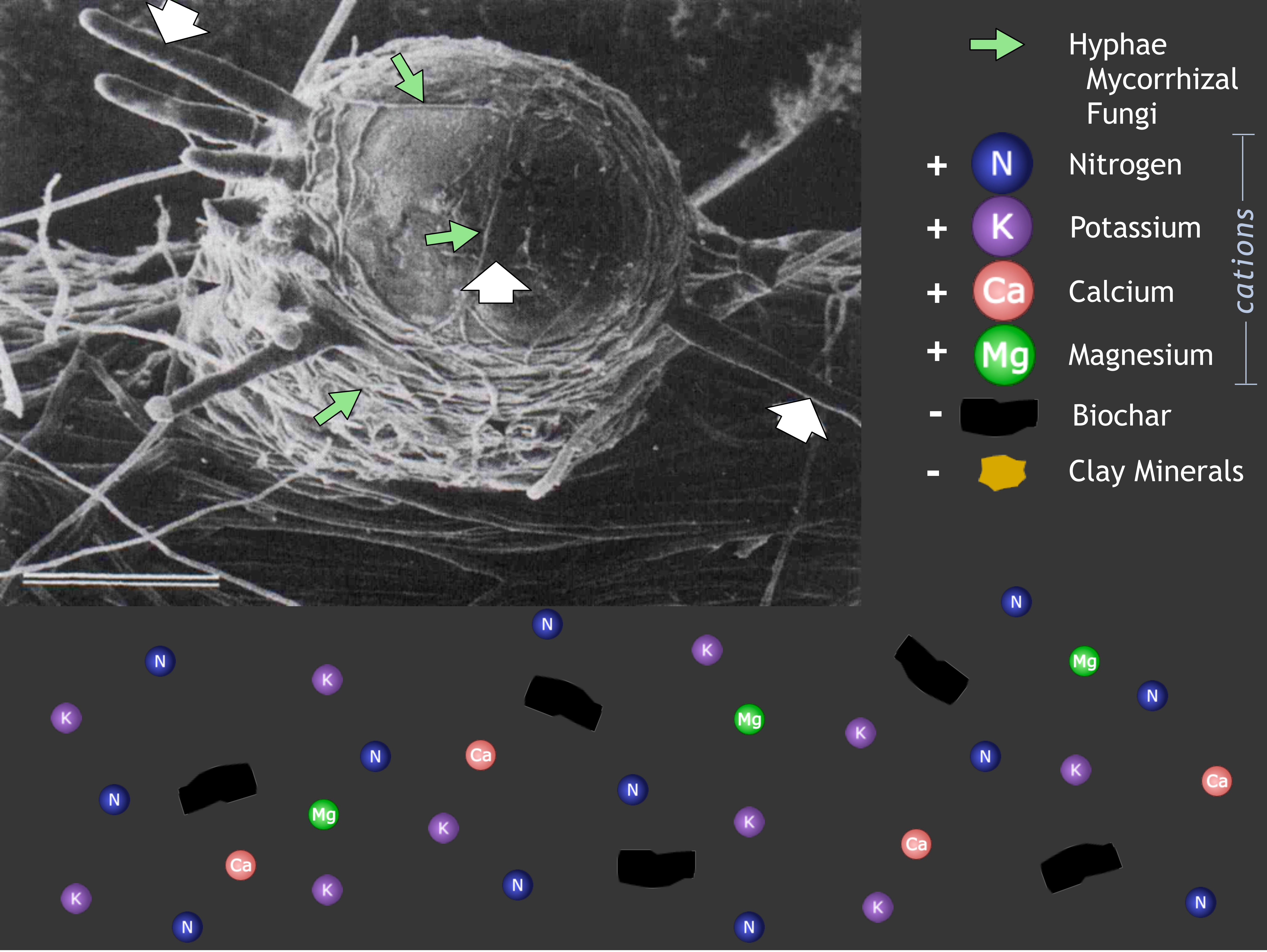
+ Mg Magnesium

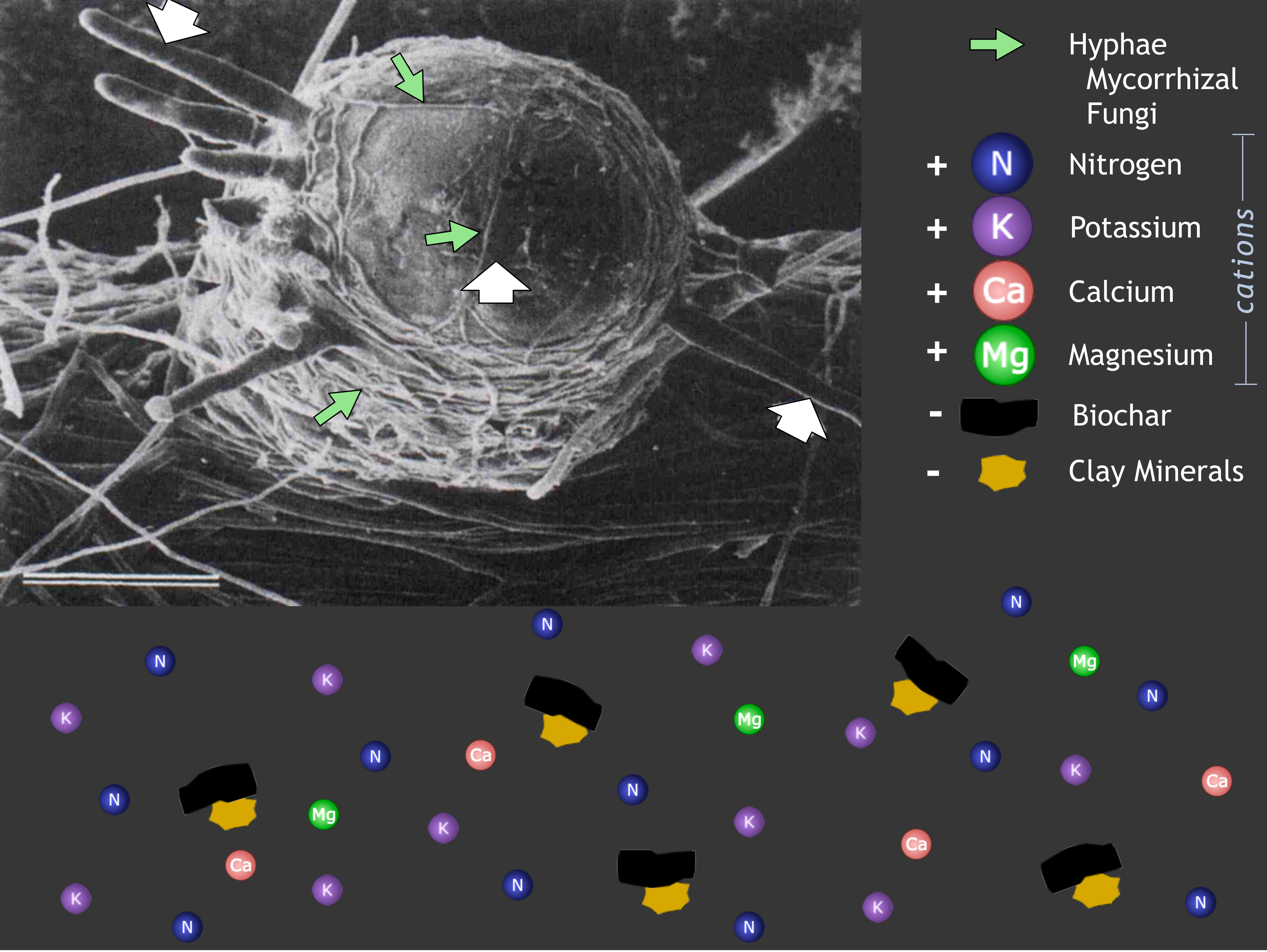
\- Biochar

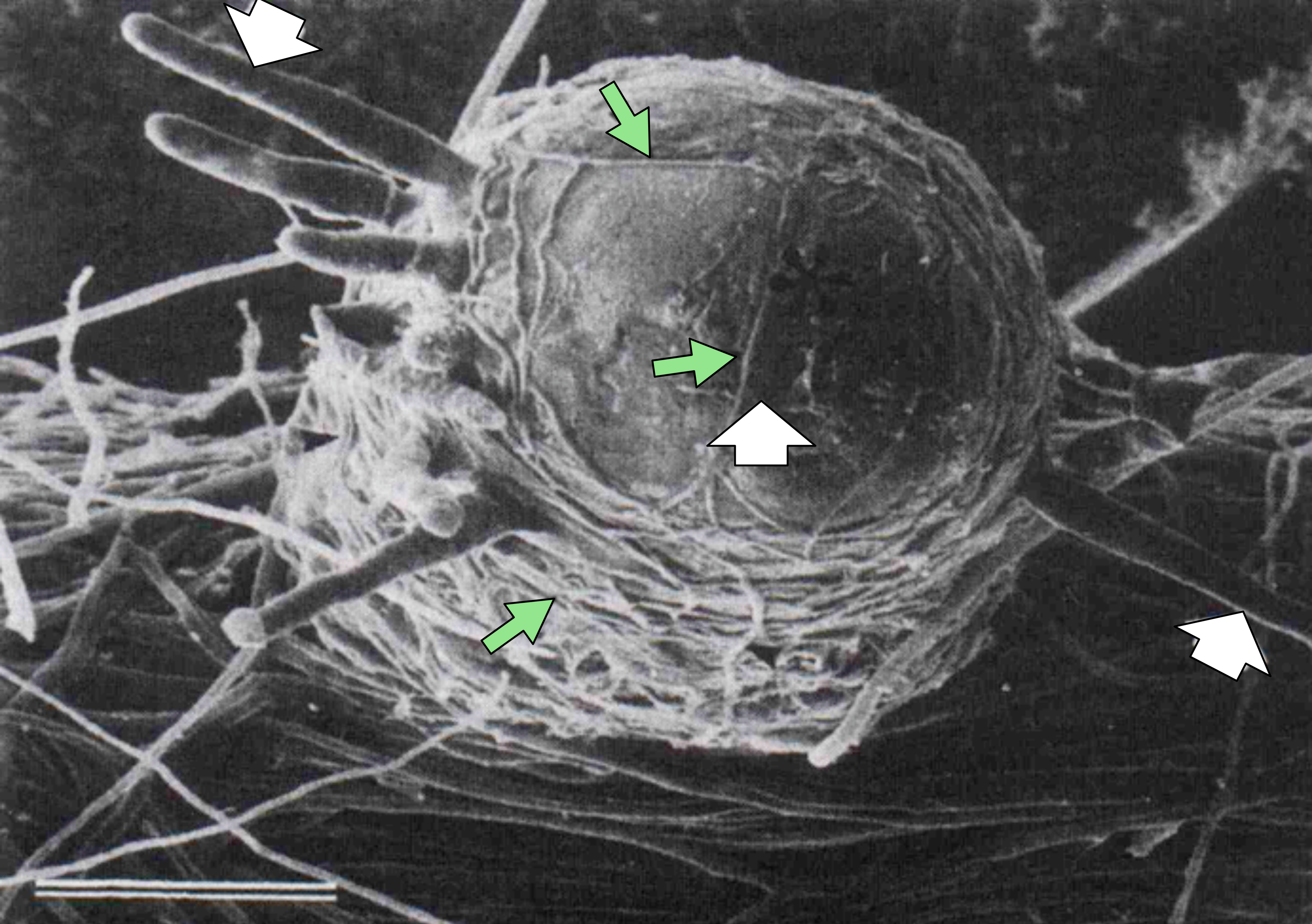
cations




Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
- Biochar
Clay Minerals
cations


Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
cations
- Biochar
- Clay Minerals


Hyphae
Mycorrhizal
Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
cations
- Biochar
- Clay Minerals



Hyphae Mycorrhizal Fungi

\+ N Nitrogen

\+ K Potassium

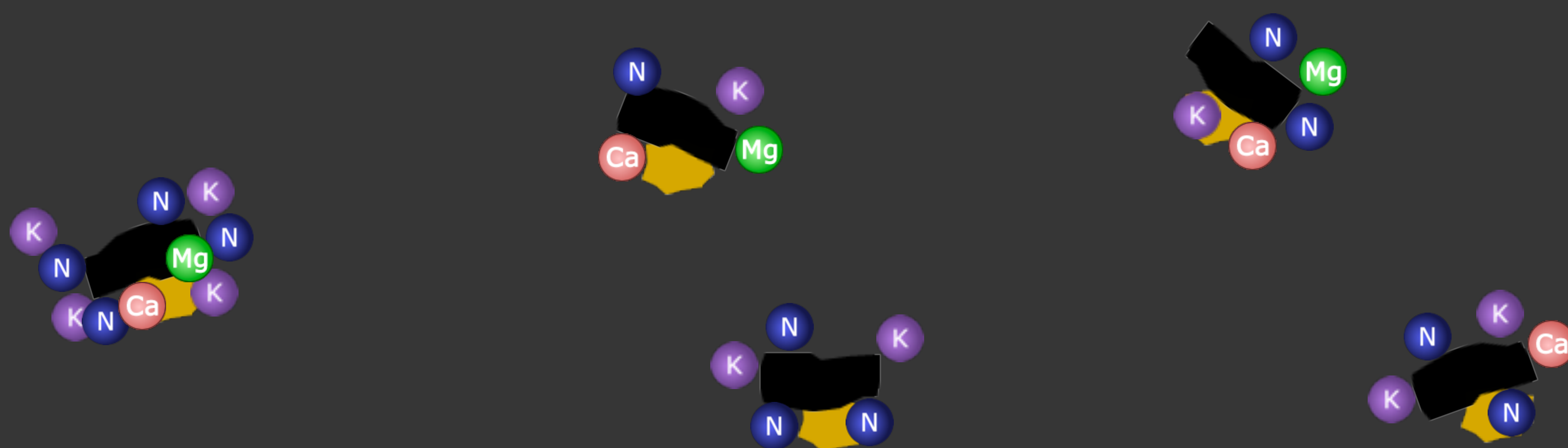
\+ Ca Calcium

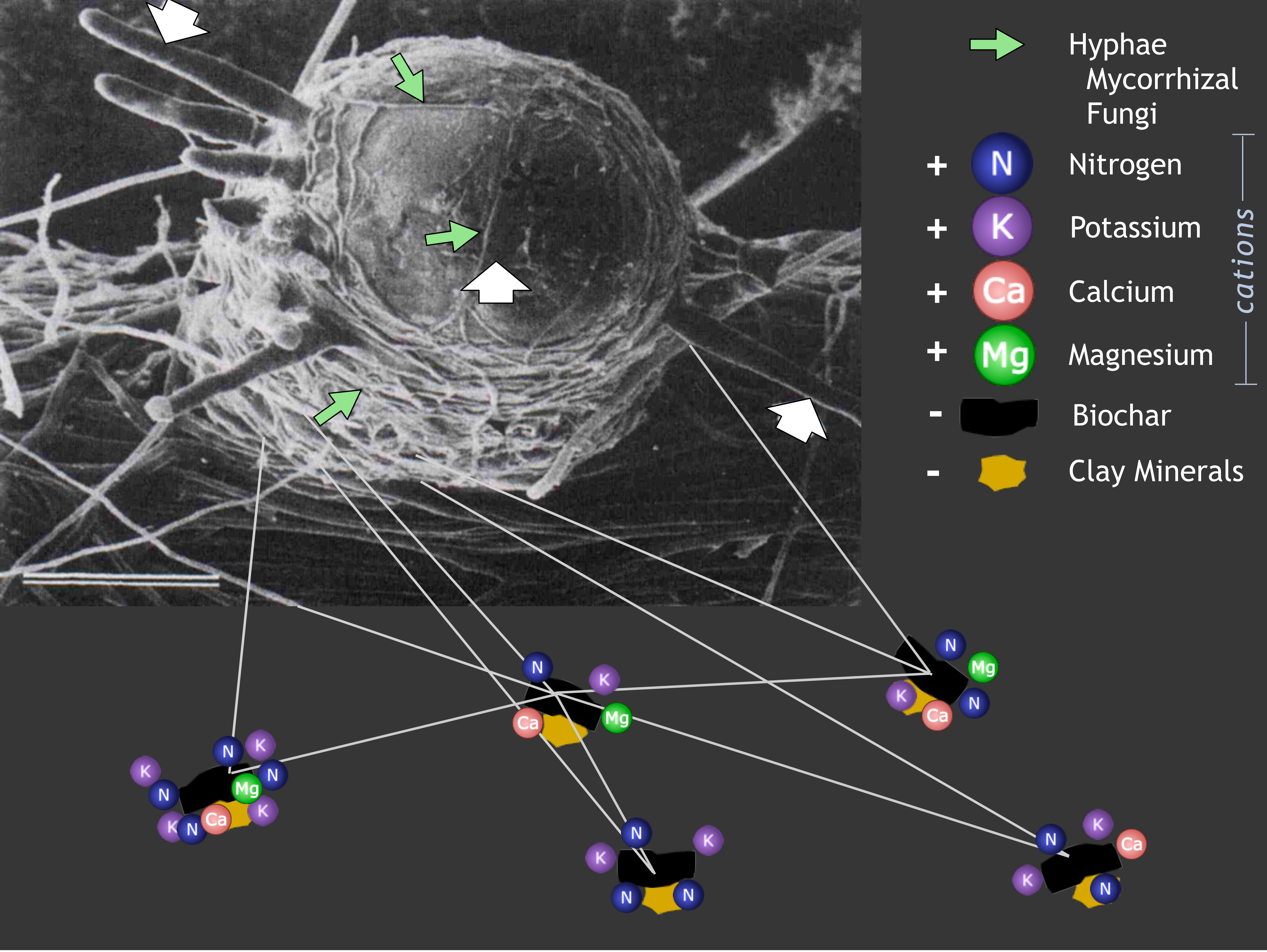
\+ Mg Magnesium

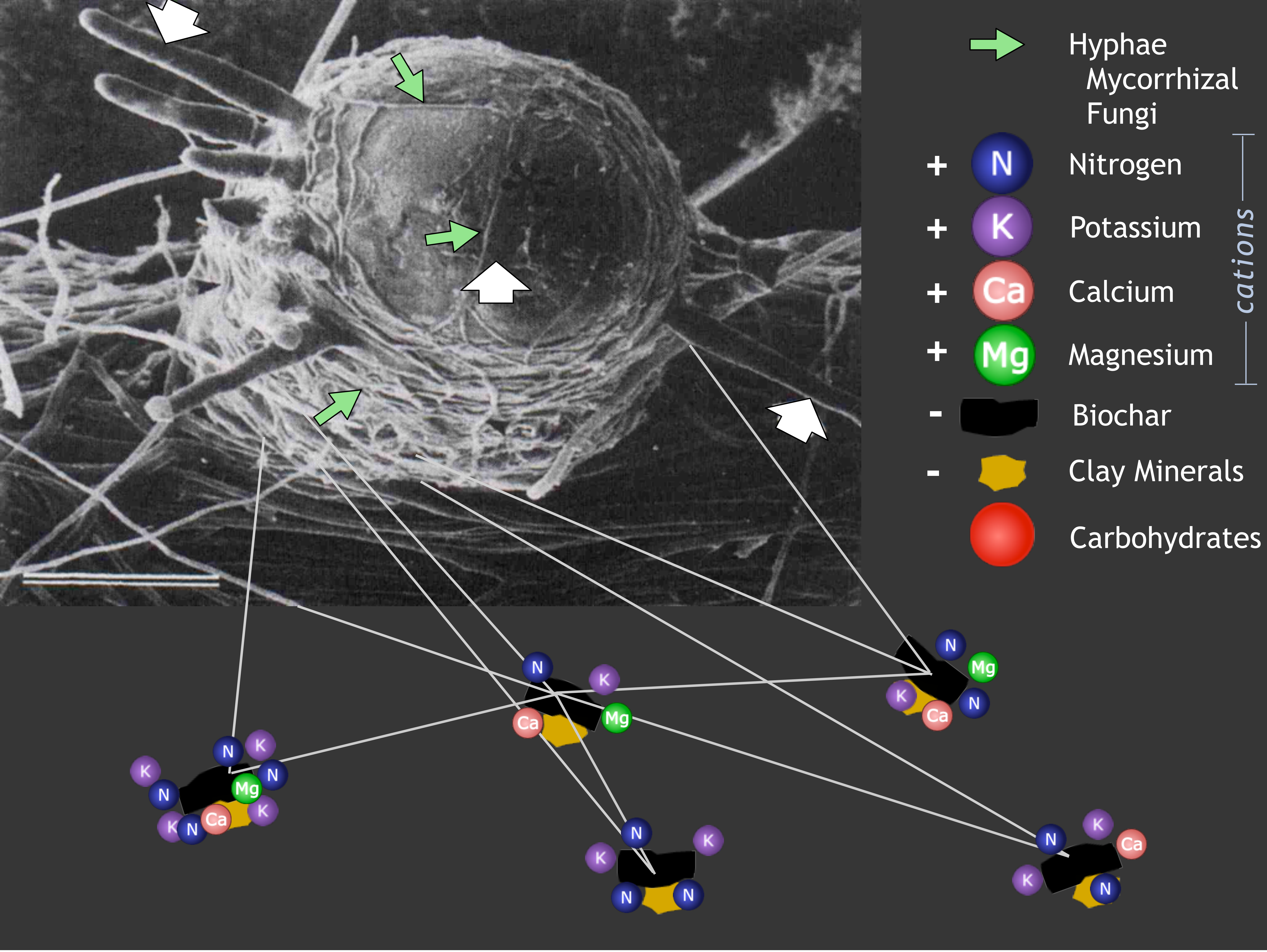
\- Biochar

\- Clay Minerals

cations




Hyphae Mycorrhizal Fungi
+ N Nitrogen
+ K Potassium
+ Ca Calcium
+ Mg Magnesium
- Biochar
- Clay Minerals
cations
N
K
Ca
Mg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Carbohydrates
N
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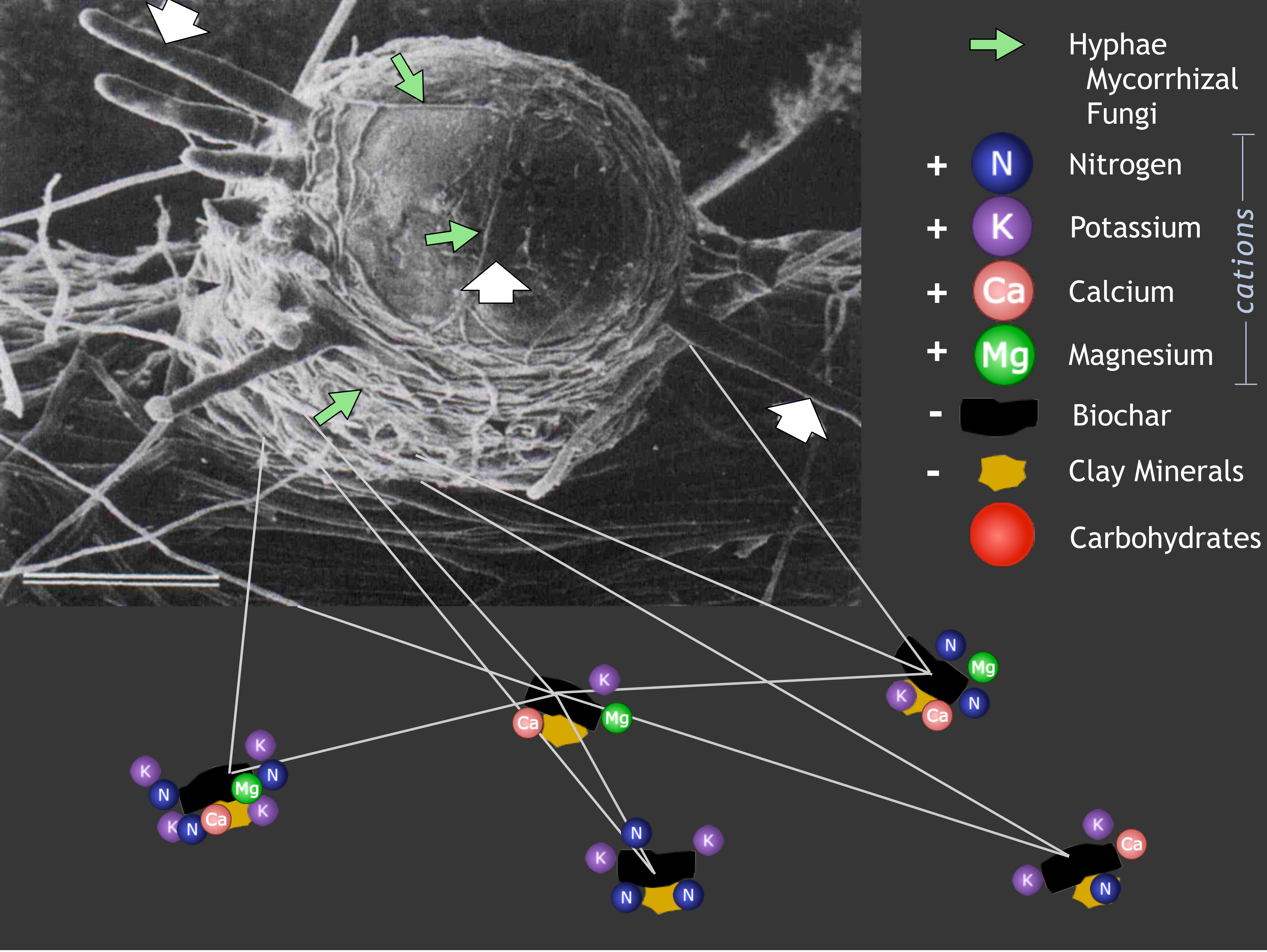
Ca
Mg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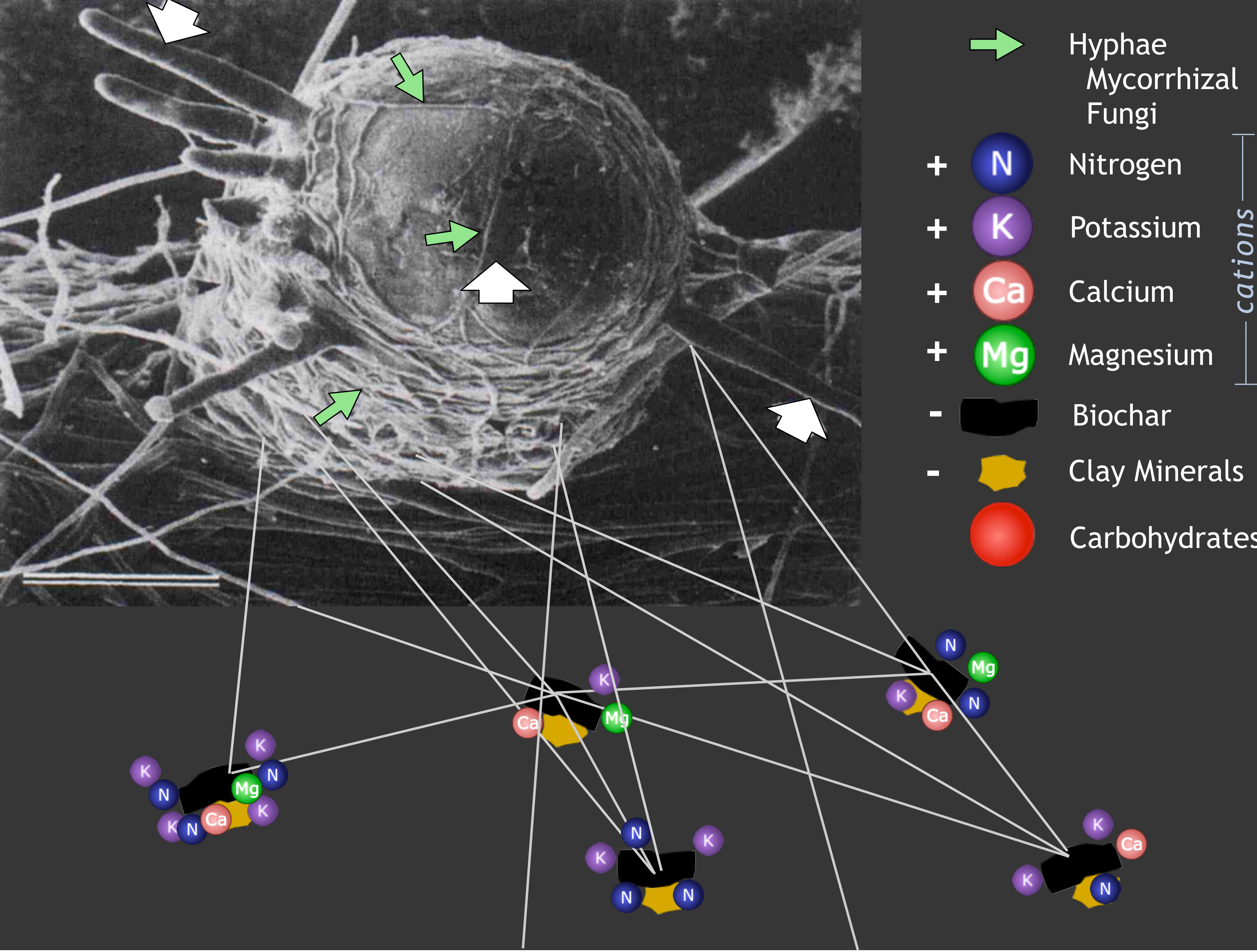
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CarbonZero

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- Biochar-clay complexes, when properly prepared, have a (much) greater CEC potential.

Carbon Zero PROJECT