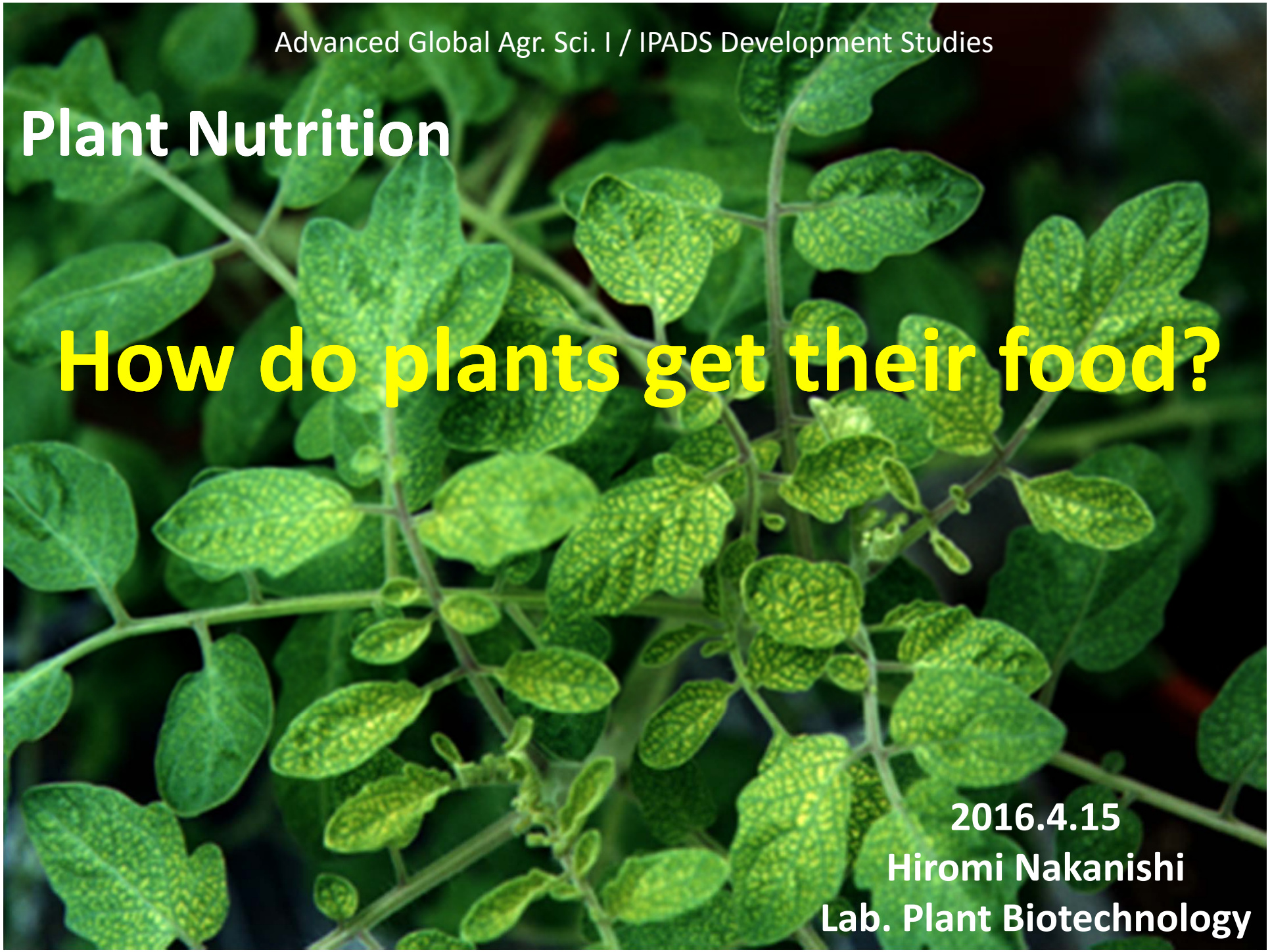
Advanced Global Agr. Sci. I / IPADS Development Studies
Plant Nutrition
How do plants get their food?
2016.4.15
Hiromi Nakanishi
Lab. Plant Biotechnology

What did you eat for lunch?

Why did you choose it?

Do you think about your health?

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Food = nutrients

Macro nutrients
- Carbohydrates
- Proteins
- Fats (oils)

Micro nutrients
- Vitamins
- Minerals

Question?

What is the food for plants?

How do plants get the food?

Plants cannot move very much,

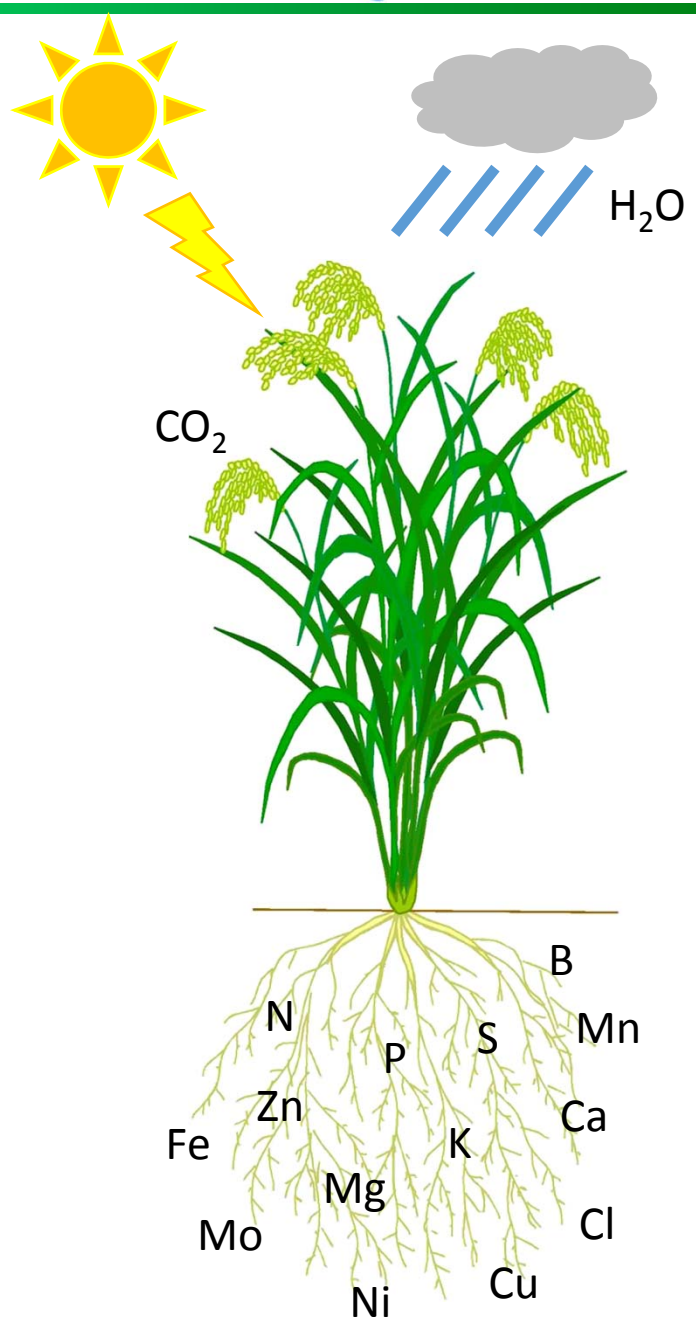
So, they must obtain nutrients from its surroundings.

Pitcher plants

Venus flytrap

Plants need

- **Sun** as an energy source
- **Inorganic** compounds
  as raw materials
    water
    CO_2
    minerals



What is “Plant Nutrition”?

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Plant nutrition is a study that deals with plants’ need for certain chemical elements including their specific and interactive effects on all aspects of plant growth and development, their availability, absorption, transport, and utilization.

植物栄養学は、植物が何を、どのように吸収、代謝して、自らの細胞を作り上げ維持しているかを明らかにしようとする学問領域である。

Food security and sustainability 食料安全保障と持続可能性

Human health 人の健康

Environmental protection 環境保全

Etc.

What are the essential elements?

Essential elements necessary for plant growth are split into three categories (Arnon and Stout 1939; Epstein 1972)

1. **The element must be required for the completion of the life cycle of the plant.**
   その元素が欠乏するとライフサイクルが完結できない。

2. **The element must not be replaceable by another element in whole.**
   その元素による生育障害はその元素の添加によってのみ回復する。

3. **The element must be directly involved in the metabolism of the plant, i.e. required for a specific physiological function in the plant.**
   その元素を構成要素とする細胞に必要な細胞成分や酵素が存在する。

Question?

How the element X is proved to be essential for plant growth?

Hydroponics

Complete solution containing all minerals (control)

Solution lacking potassium (experimental)

Figure 32.6

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Macro nutrients (9)

Plants require these nutrients in relatively large amounts

Element	Form available to plants	% Mass in dry tissue	Major functions
Carbon (C)	CO_2	45%	Major component of organic compounds
Oxygen (O)	CO_2, H_2O	45%	Major component of organic compounds
Hydrogen (H)	H_2O	6%	Major component of organic compounds
Nitrogen (N)	NO_3^-, NH_4^+	1.5%	Protein, nucleic acids, chlorophyll
Potassium (P)	K+	1.0%	Stomatal control, water balance
Calcium (Ca)	Ca^{2+}	0.5%	Cell wall & membrane structure, regulation
Magnesium (Mg)	Mg^{2+}	0.2%	chlorophyll
Phosphorus (P)	$H_2PO_4^-$, HPO_4^{2-}	0.2%	Nucleic acids, ATP, phospholipids
Sulfur (S)	SO_4^{2-}	0.1%	Proteins, enzymes

Micro nutrients (8)

Plants require in very small amounts

Element	Form available to plants	% Mass in dry tissue	Major functions
Chlorine (Cl)	Cl^-	0.01%	Photosynthesis, water balance
Iron (Fe)	Fe^{2+}, Fe^{3+}	0.01%	Cytochromes, redox, photosysnthesis
Manganese (Mn)	Mn^{2+}	0.005%	Enzymes, photosynthesis
Boron (B)	$H_2BO_3^-$	0.002%	Cell wall
Zinc (Zn)	Zn^{2+}	0.002%	Activator or component of many enzymes
Copper (Cu)	Cu+, Cu^{2+}	<0.001%	Redox and lignin-biosynthesis enzymes
Nickel (Ni)	Ni^{2+}	<0.001%	Nitrogen metabolism
Molybdenum (Mo)	MoO_4^{2-}	<0.001%	Nitrate reduction

How do plants get the food?

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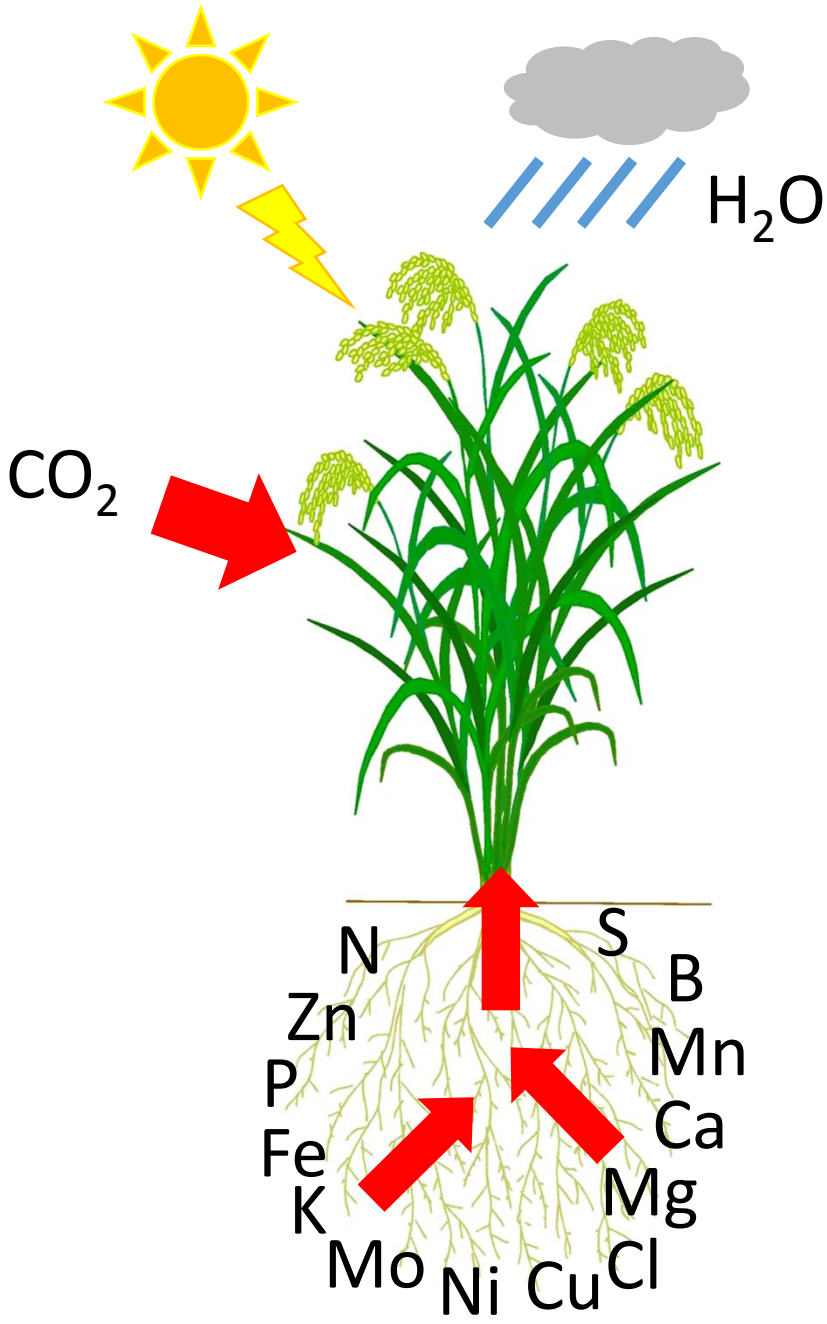

Photosynthesis

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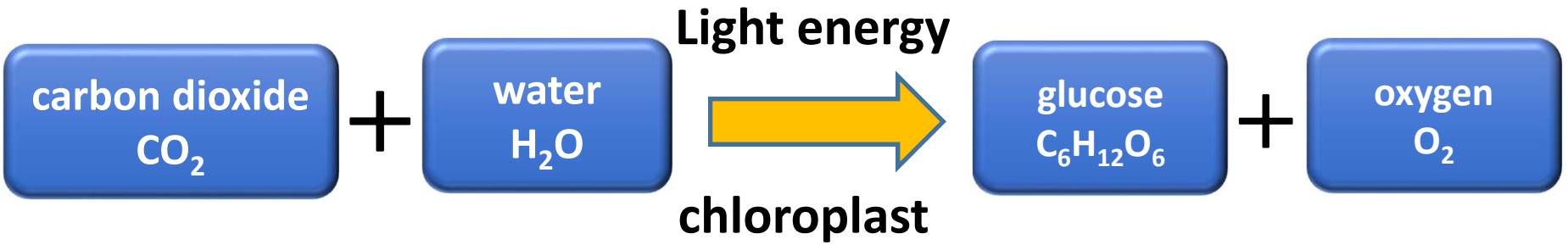
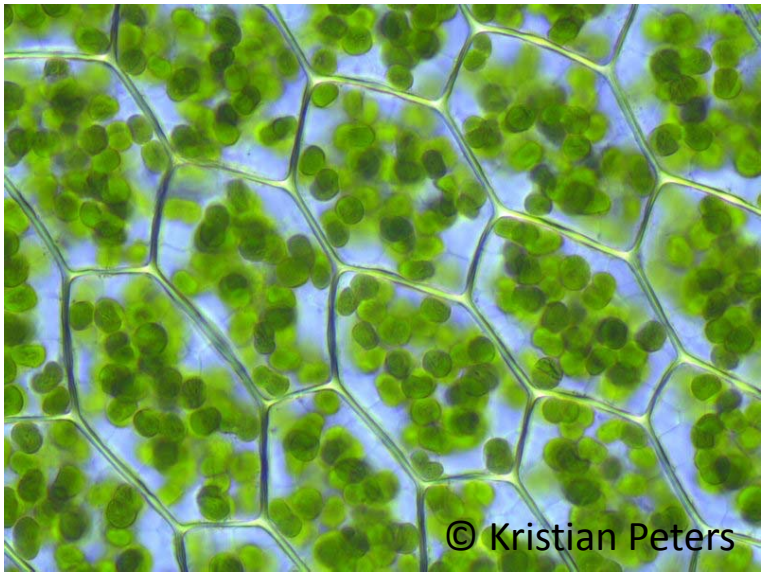
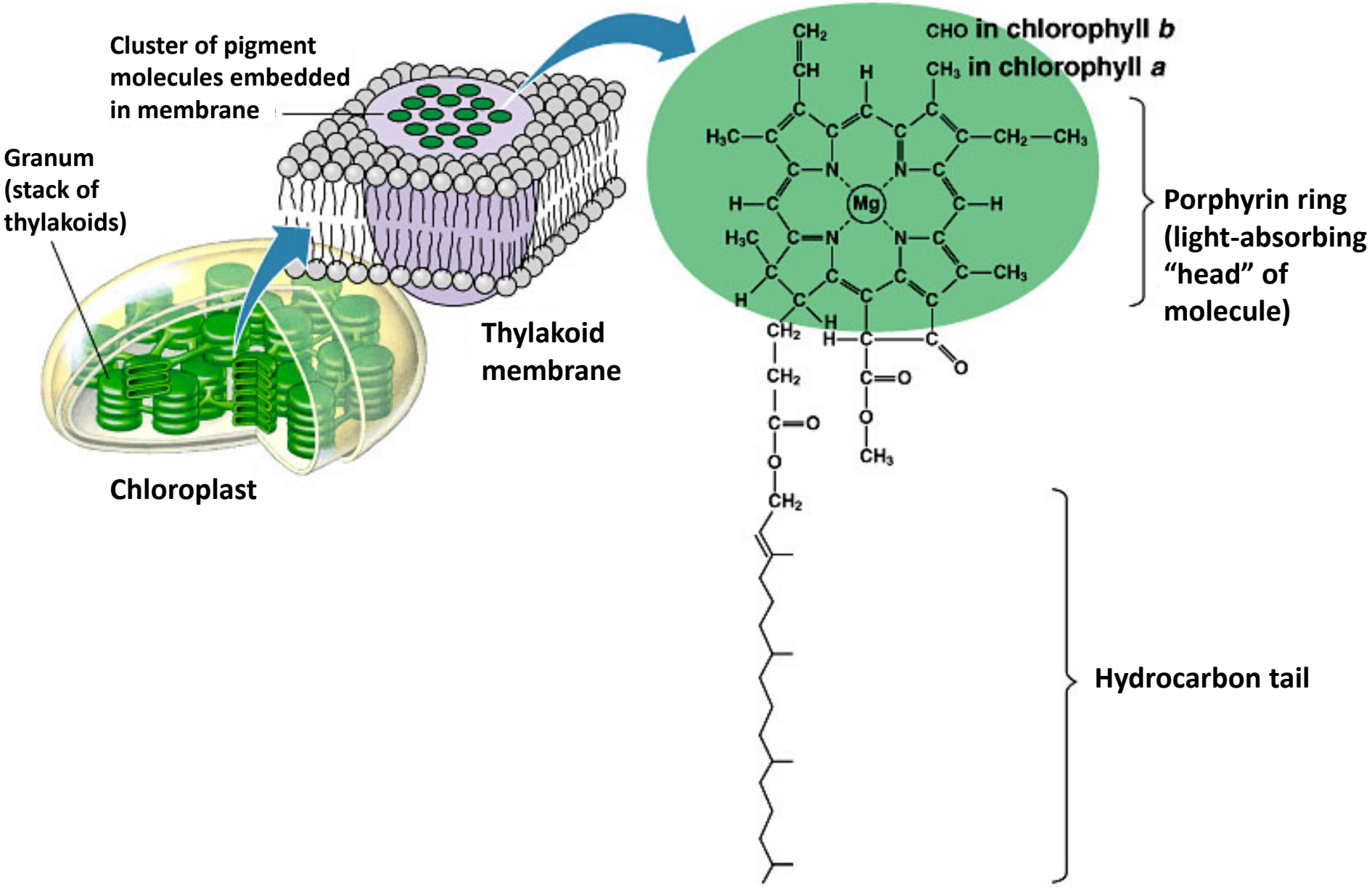


stomata

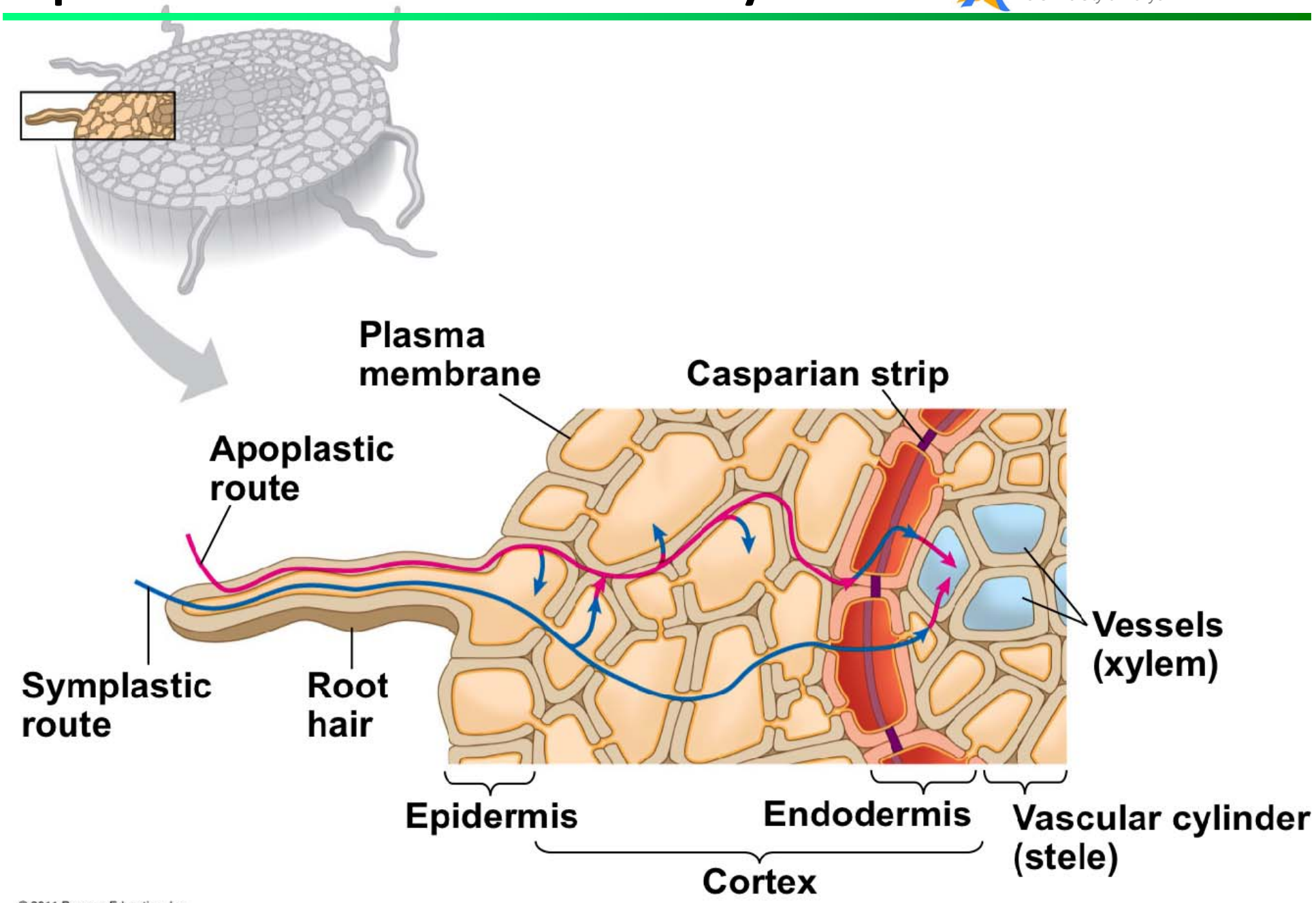


chloroplasts

Chlorophyll



Uptake of water and nutrients by roots



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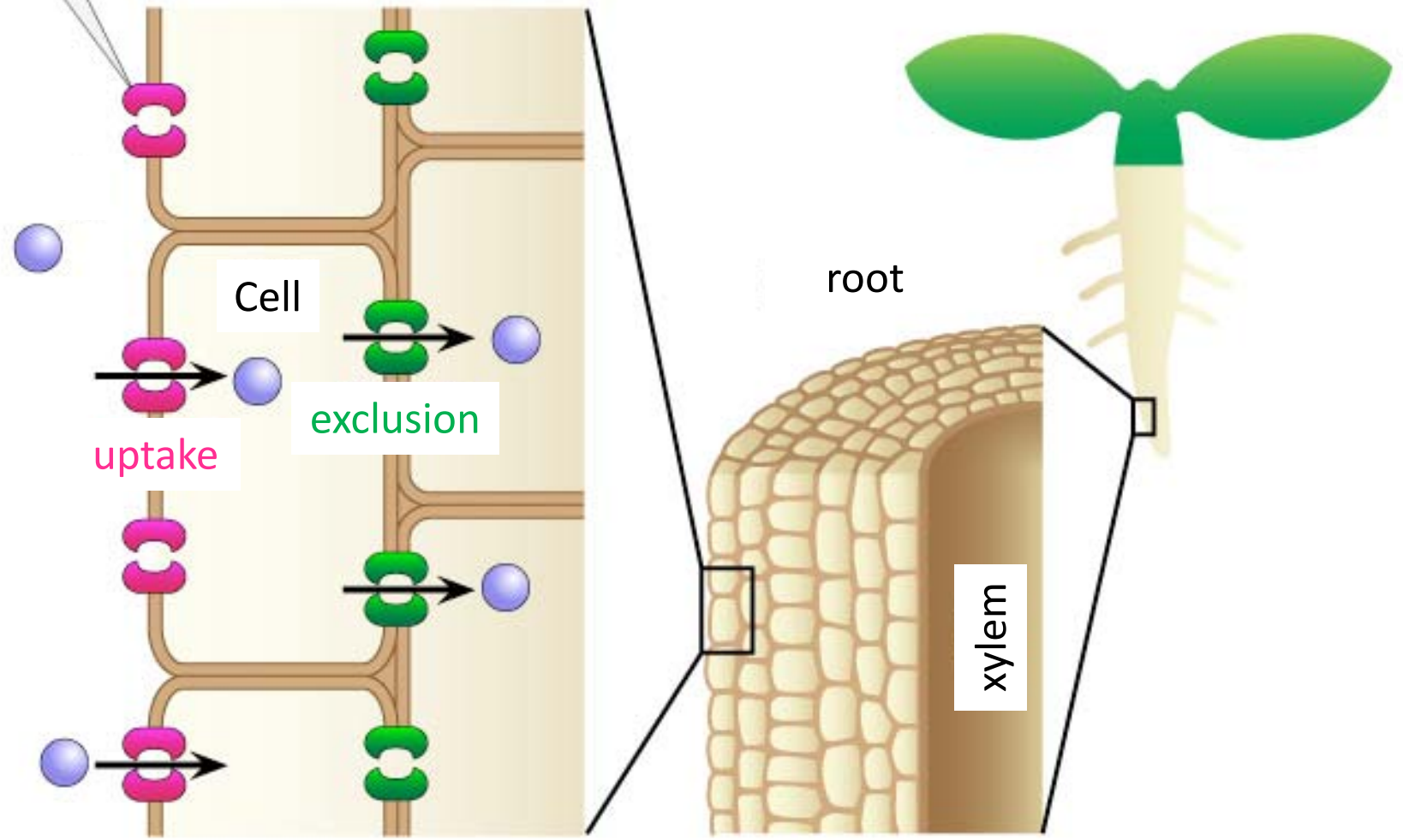
Transporter

Transporter

A membrane protein involved in the movement of ions, small molecules, etc., across a biological membrane.



Xylem and Phloem transport

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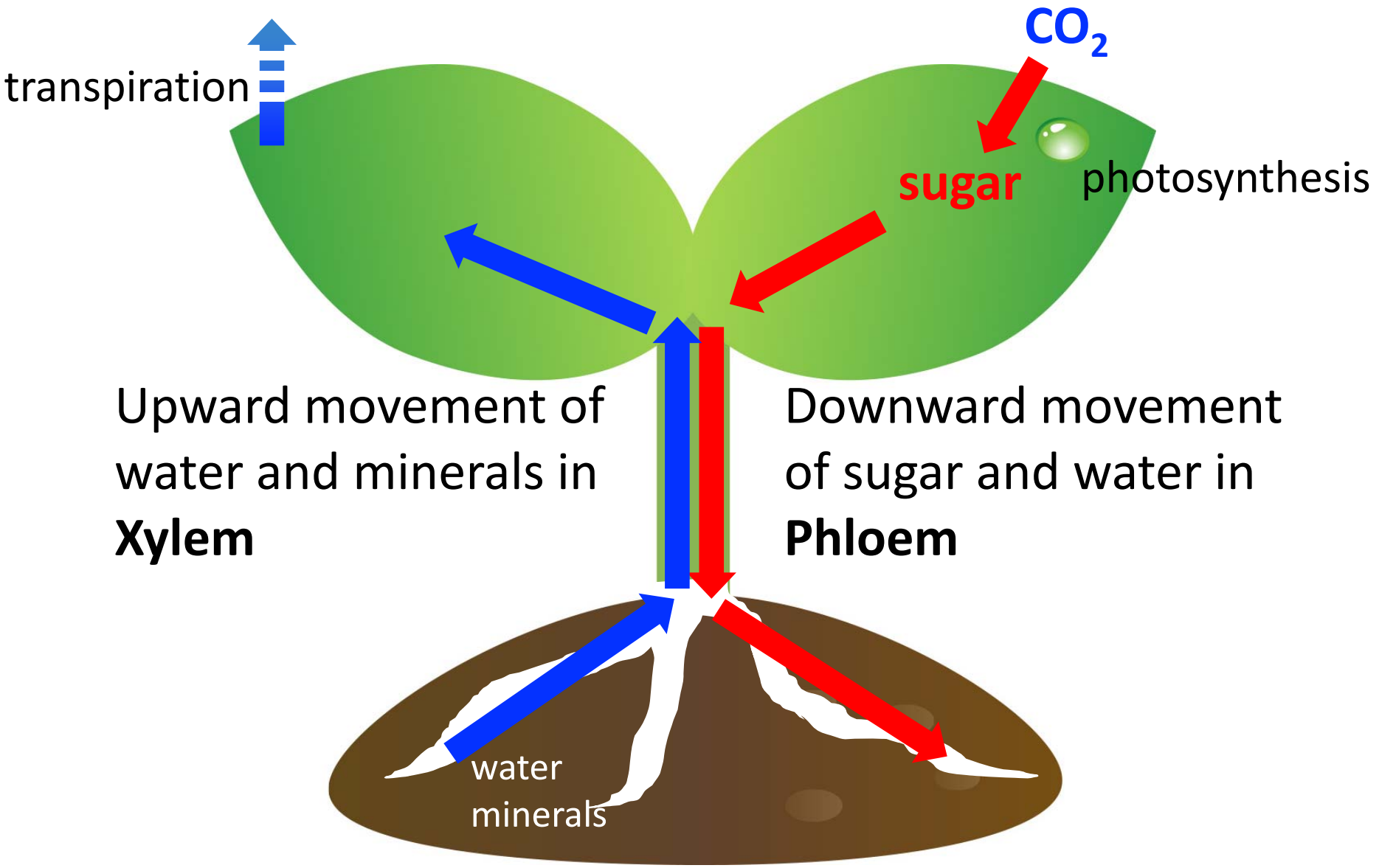

Plants need adequate amounts of elements

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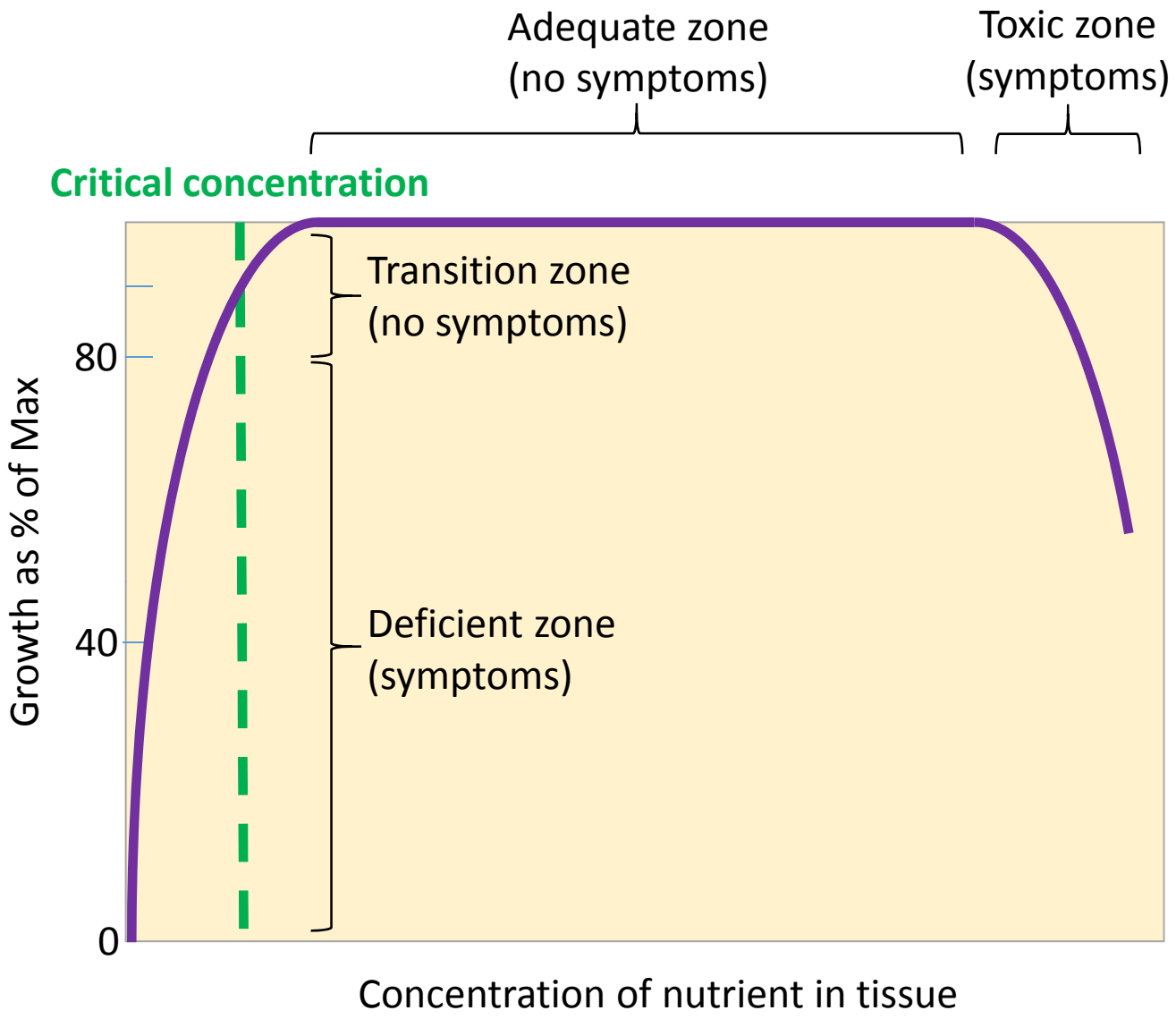

Liebig's "Law of the Minimum"

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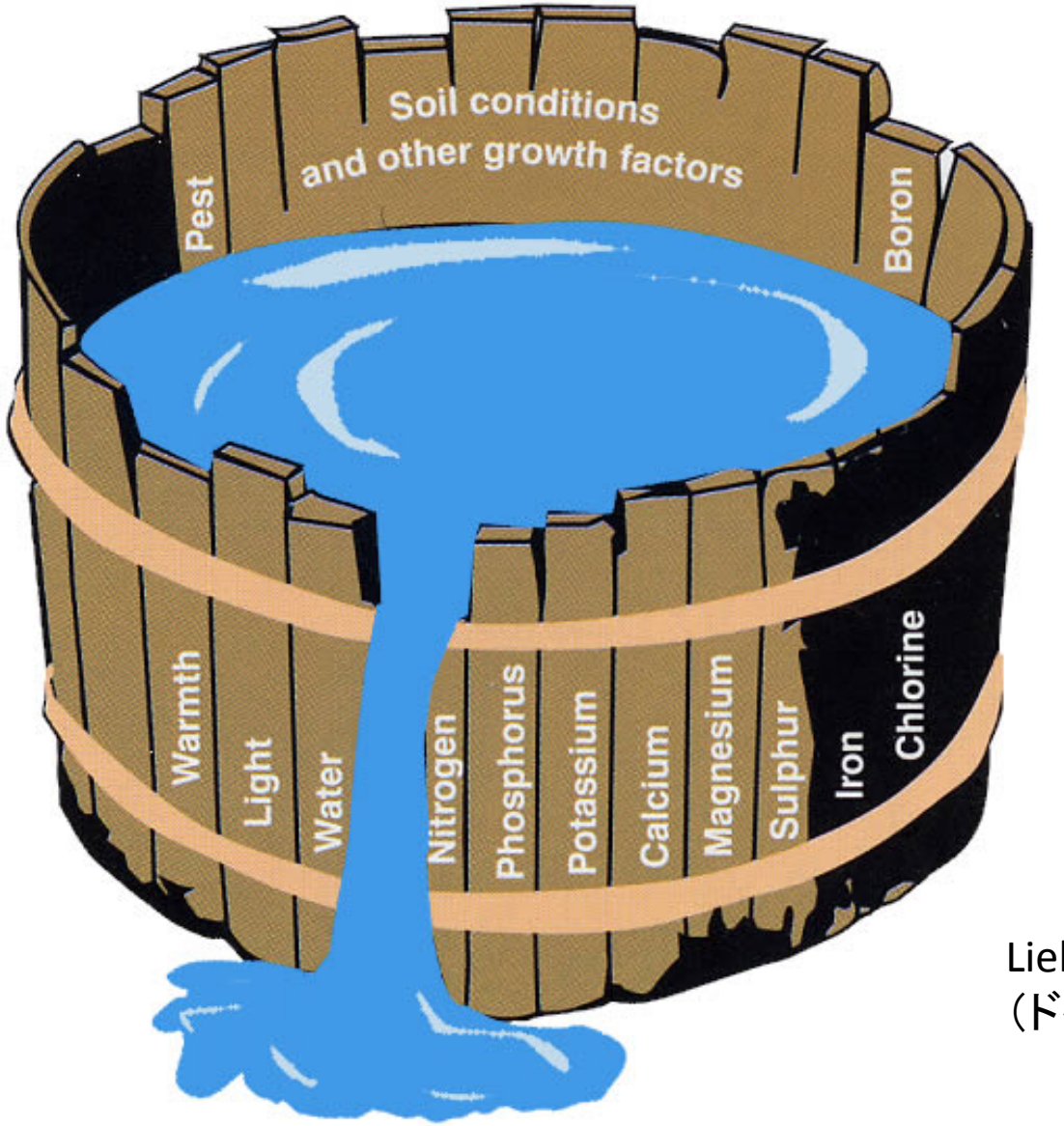
リービッヒの最小律



Liebig's Barrel
（ドベネックの桶）

Question?

If the nitrogen supply is limited,
what happens to plants?

Nitrogen deficiency

Chlorosis of the leaves

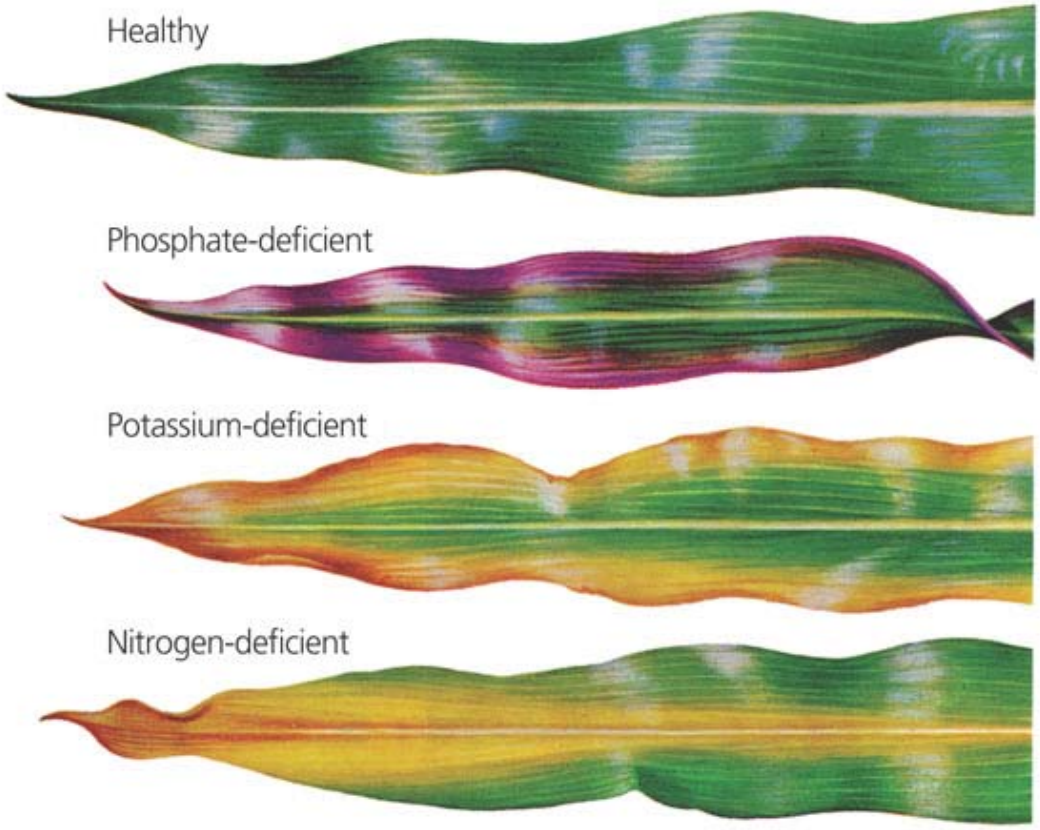
Older leaves showing symptoms first

N deficiency in tomato

(タキイ種苗）

Nutrient deficiencies

Exhibit specific symptoms
- dependent on function of nutrient
- dependent on mobility of nutrient



maize

Mg deficiency in Tomato

Fe deficiency in Tomato

(タキイ種苗）

Influence of soil pH on plant nutrient availability

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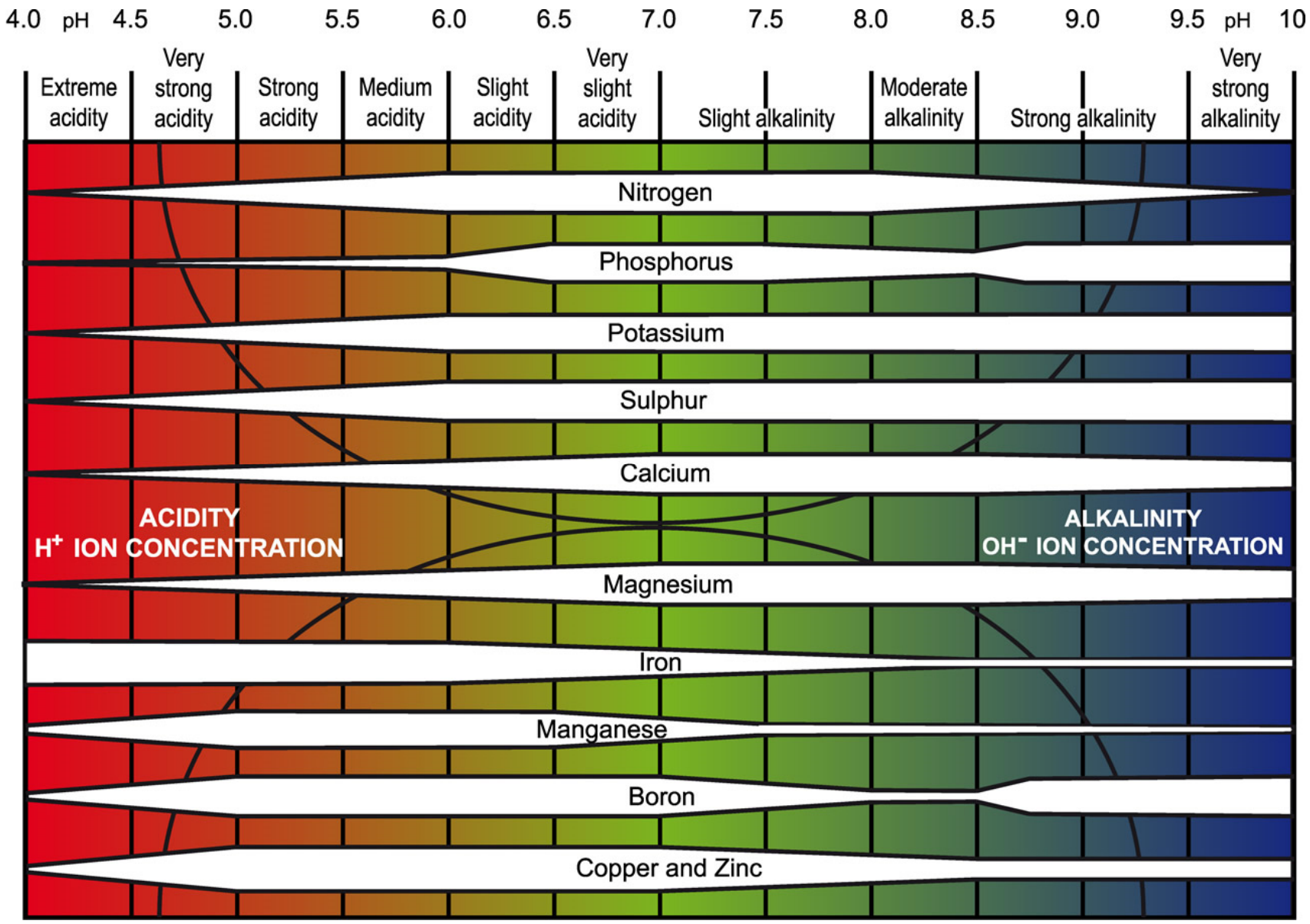
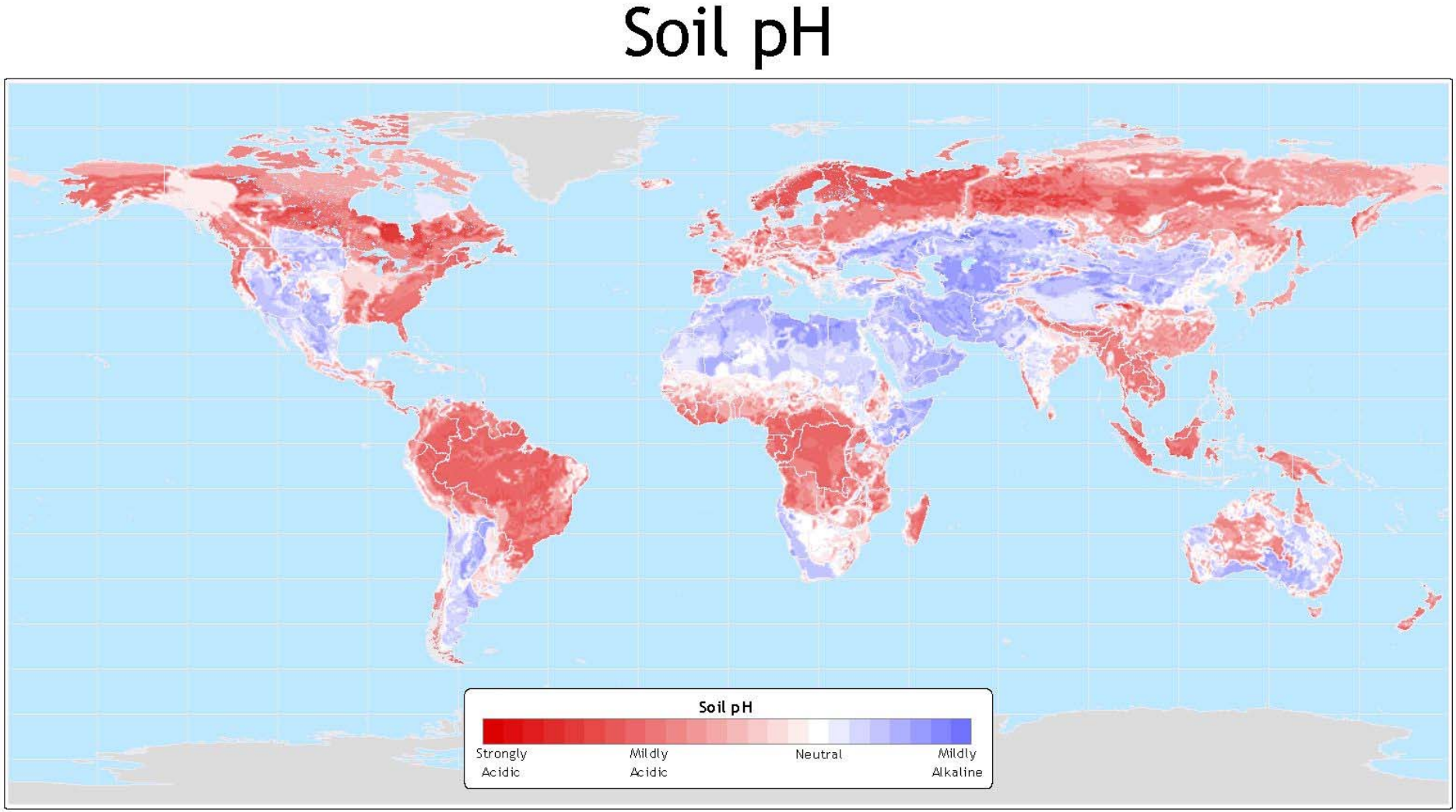


http://www.pda.org.uk

Soil pH



Data taken from: IGBP-DIS Global Soils Dataset (1998)

Atlas of the Biosphere
Center for Sustainability and the Global Environment
University of Wisconsin - Madison

Question?

If the soil is alkaline (>pH8), what happens to plants?

Fe-deficient peach (Israel)

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16 15:16

Fe-deficiency tolerant transgenic rice

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NAAT **refre1-372** **IRO2**

WT WT WT

Conventional breeding of P-deficient tolerant rice (IRRI)

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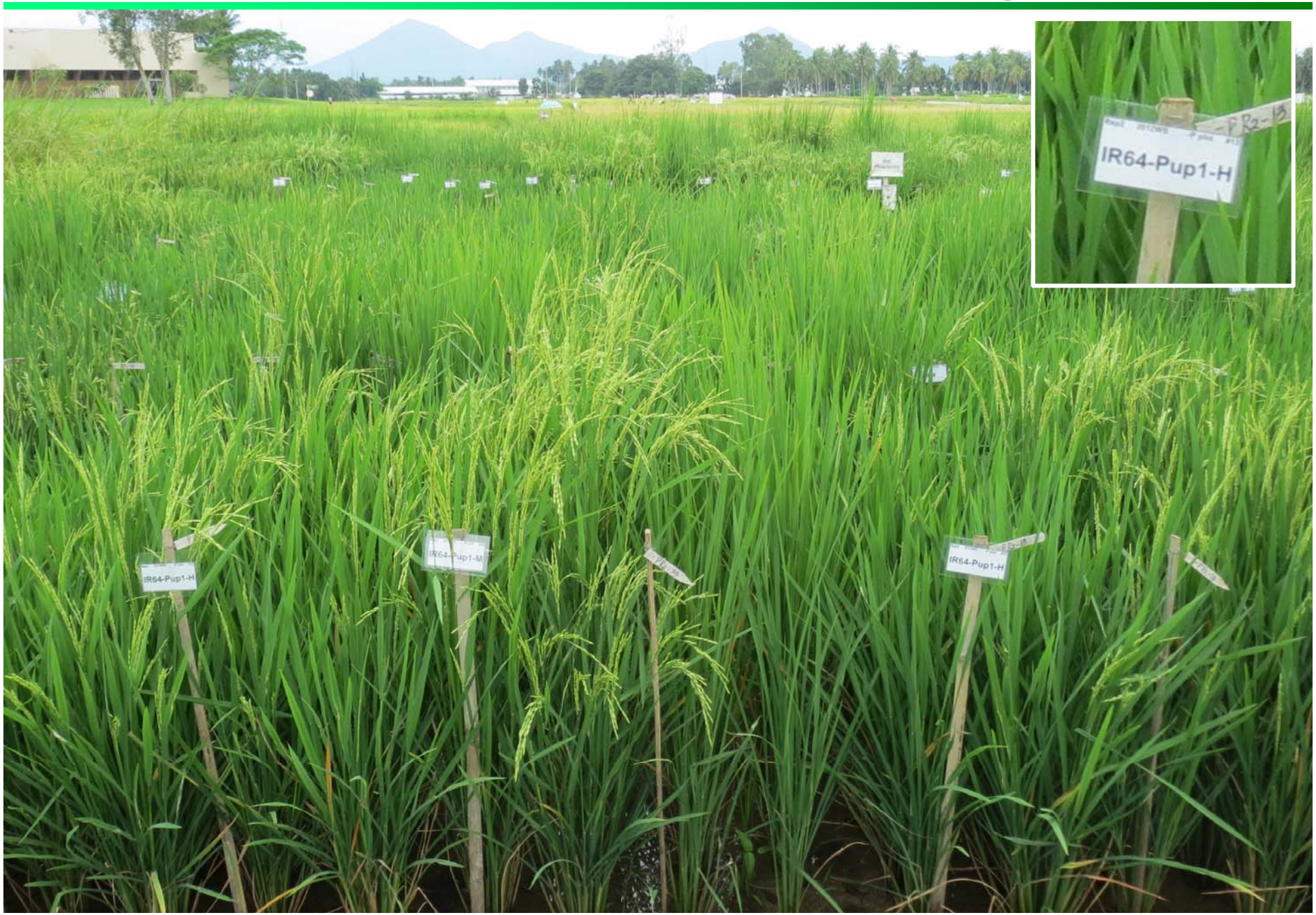

Cd-less Koshihikari mutant, *lcd-kmt1*

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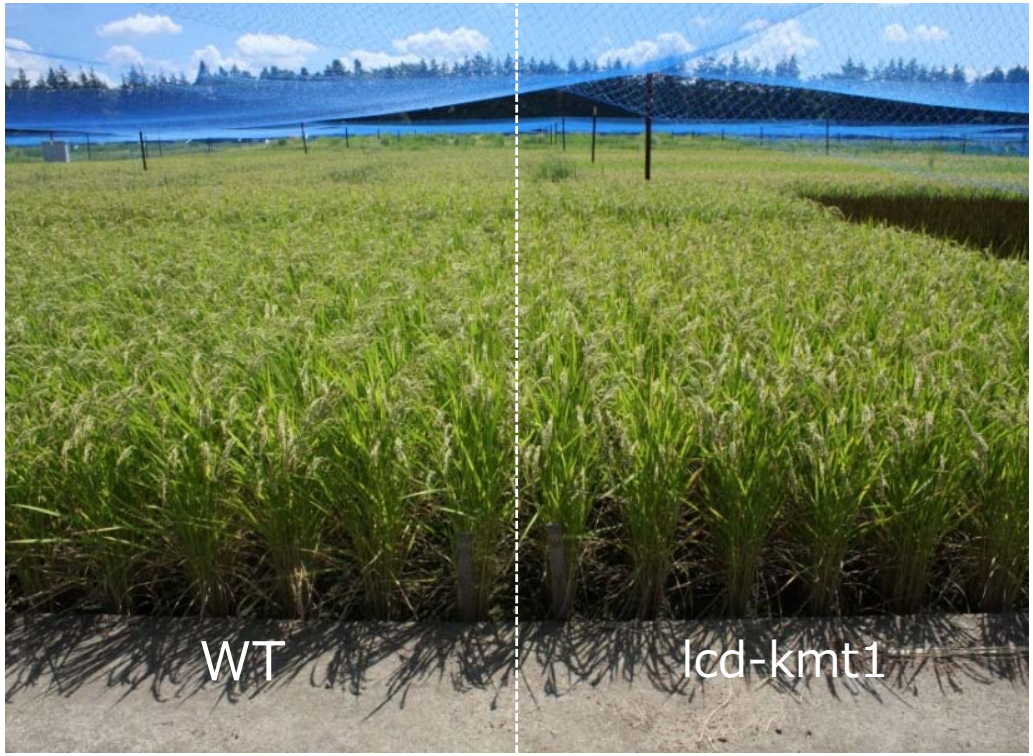

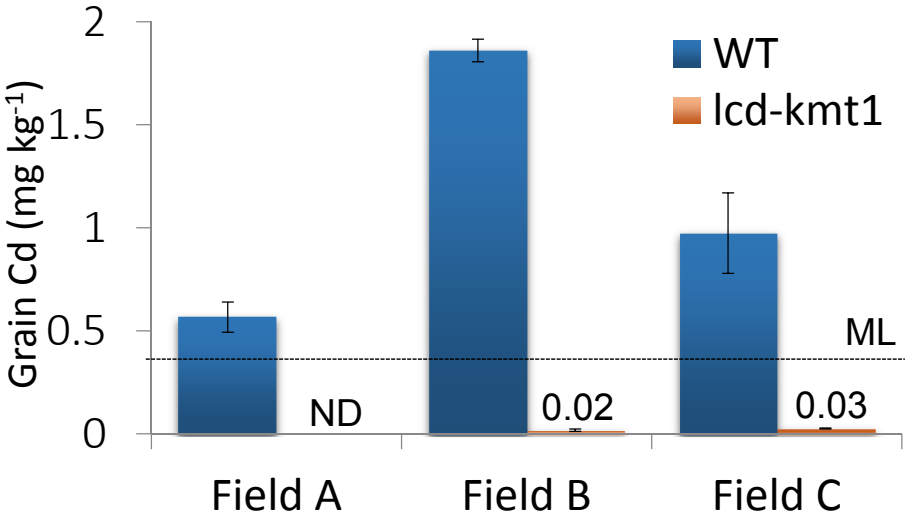

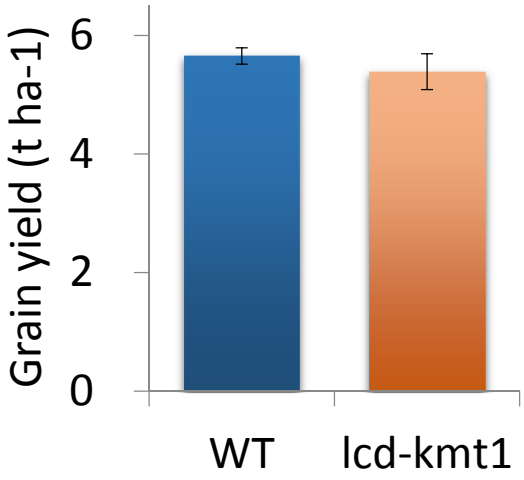

Homework

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How do plants save the earth?

How can plants/plant-biotechnology contribute to solve the existing problems in the world?

現在の世界の問題に対して植物・植物バイオテクノロジーがどのように貢献できるか？

Explain in plain words in English.

Climate change, Global warming
Pollution
Overpopulation
Natural resource depletion
Loss of biodiversity
Deforestation
Ozone layer depletion
Acid rain
Human health
……

The idea/technology must be original/new.
It is not necessary to be practicable now.

Submit your report to
report@iai.ga.a.u-tokyo.ac.jp
with your name and message.