芝生に必要な土壌学
（土壌の水分管理編）

2016年６月

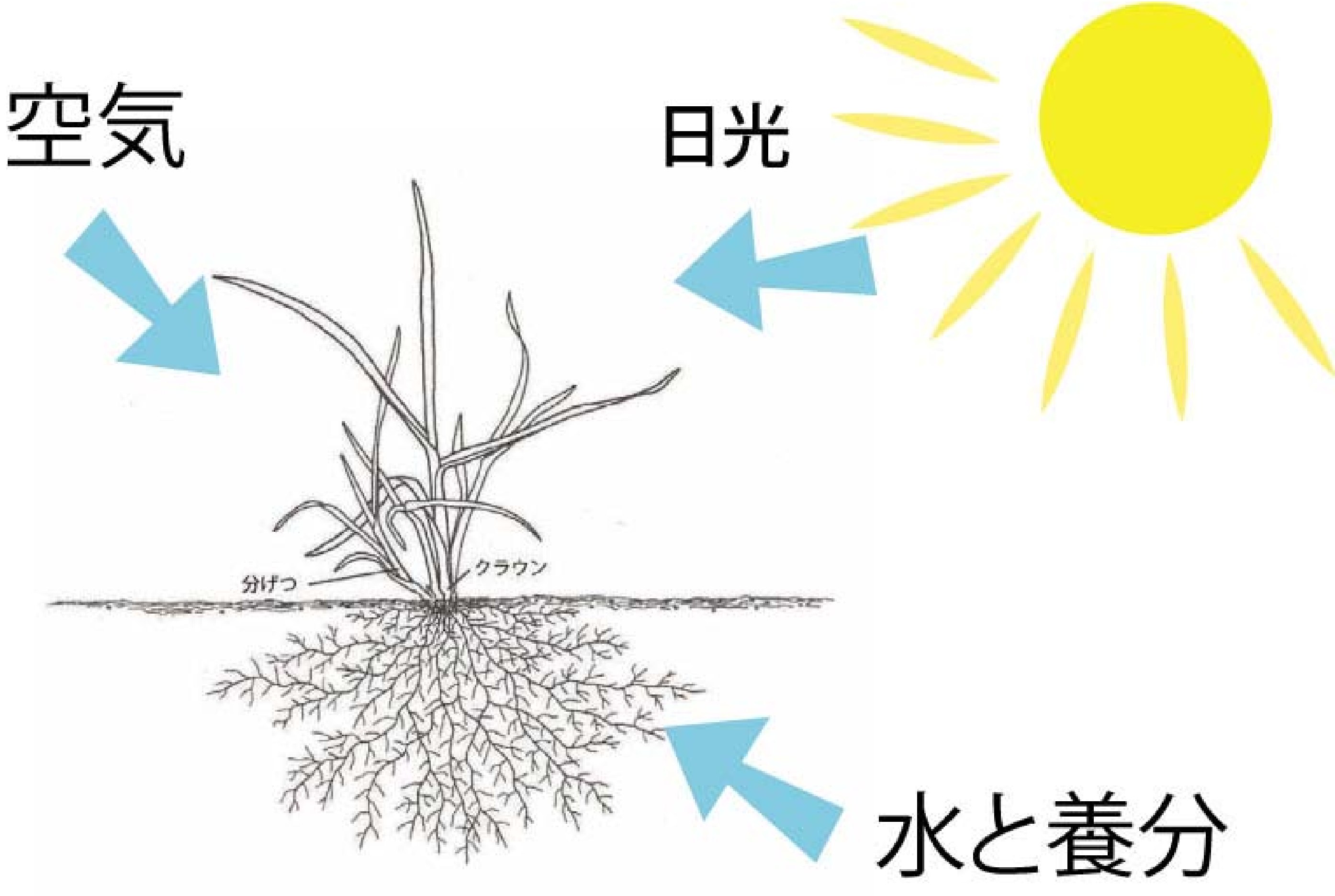
北海道グリーン研究会道南地区

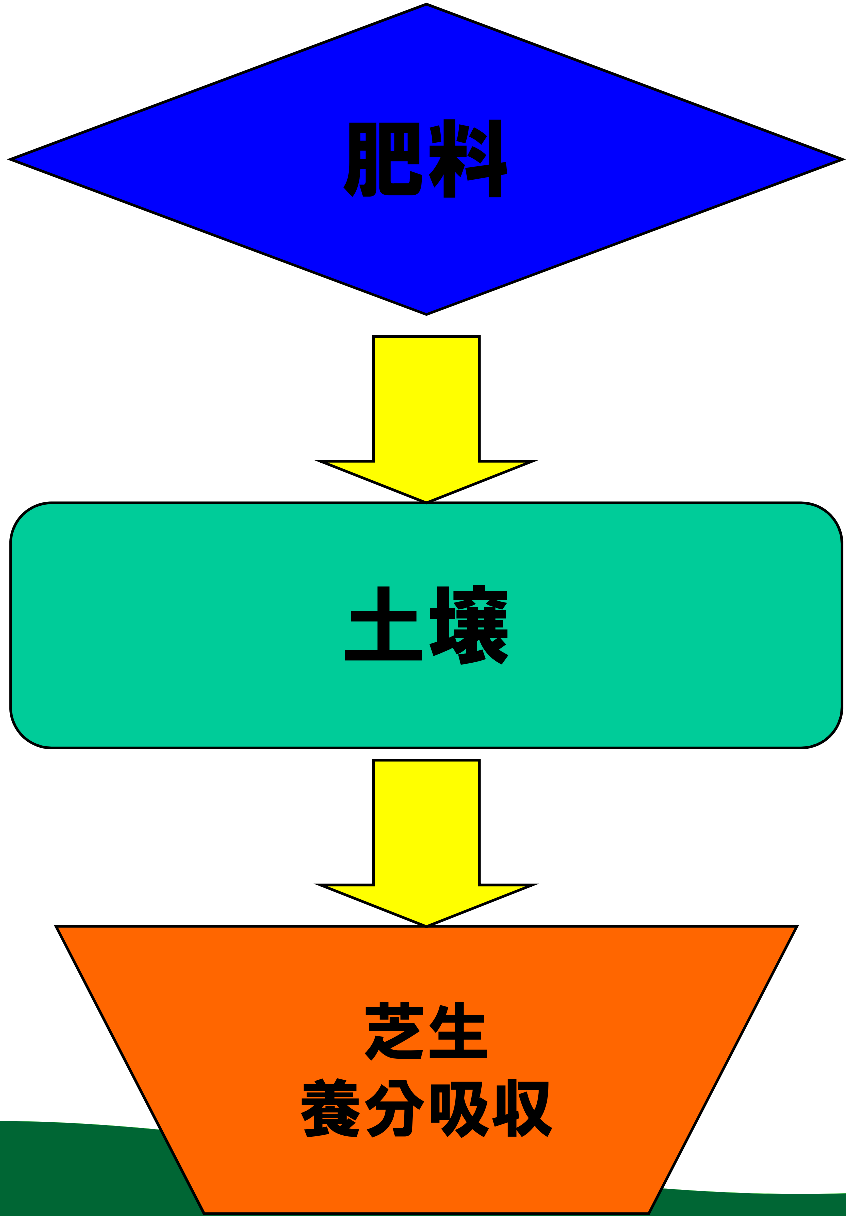
株式会社ヒューエンタープライズ

植物の成長に必要なもの？

- 太陽光（赤外線）
- 空気（CO_2）
- 水（H_2O)
- 肥料養分（N,P,K,Ca,Mg,S・・・）

植物成長に必要なもの





肥料の中身は？

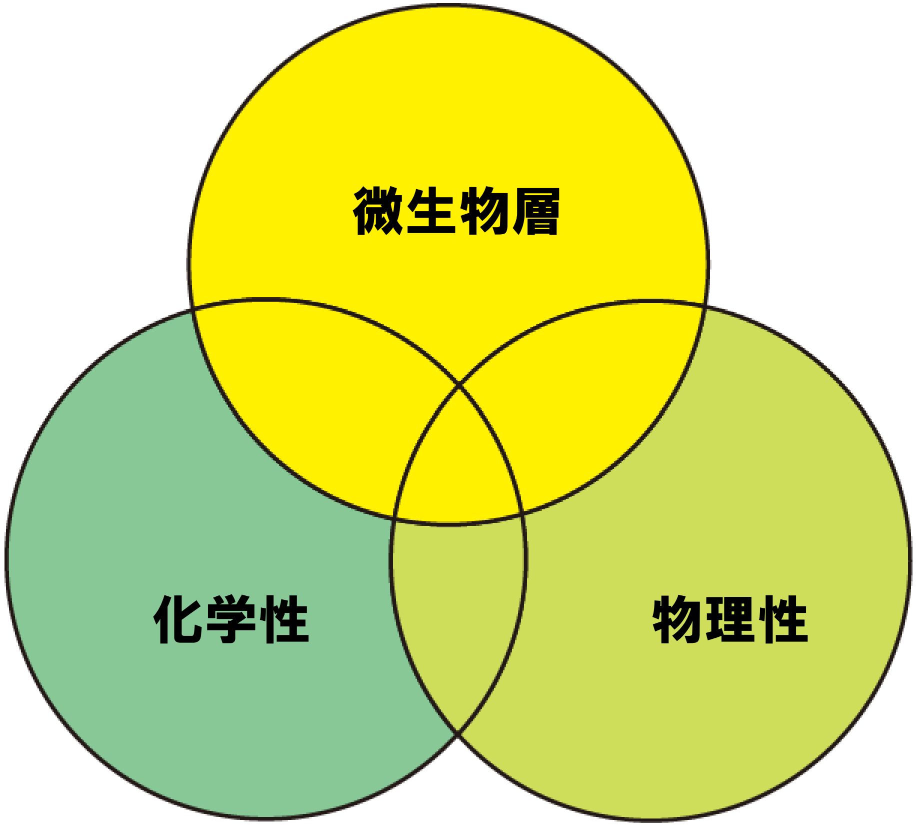
土壌の物理性
化学性・微生物層は？
土壌温度は？

根の張り
芝種
植物の健康状態は？
気象条件は？

土壌とは何か？

土壌の構成要素

有機物･酸素･水分･養分･温度



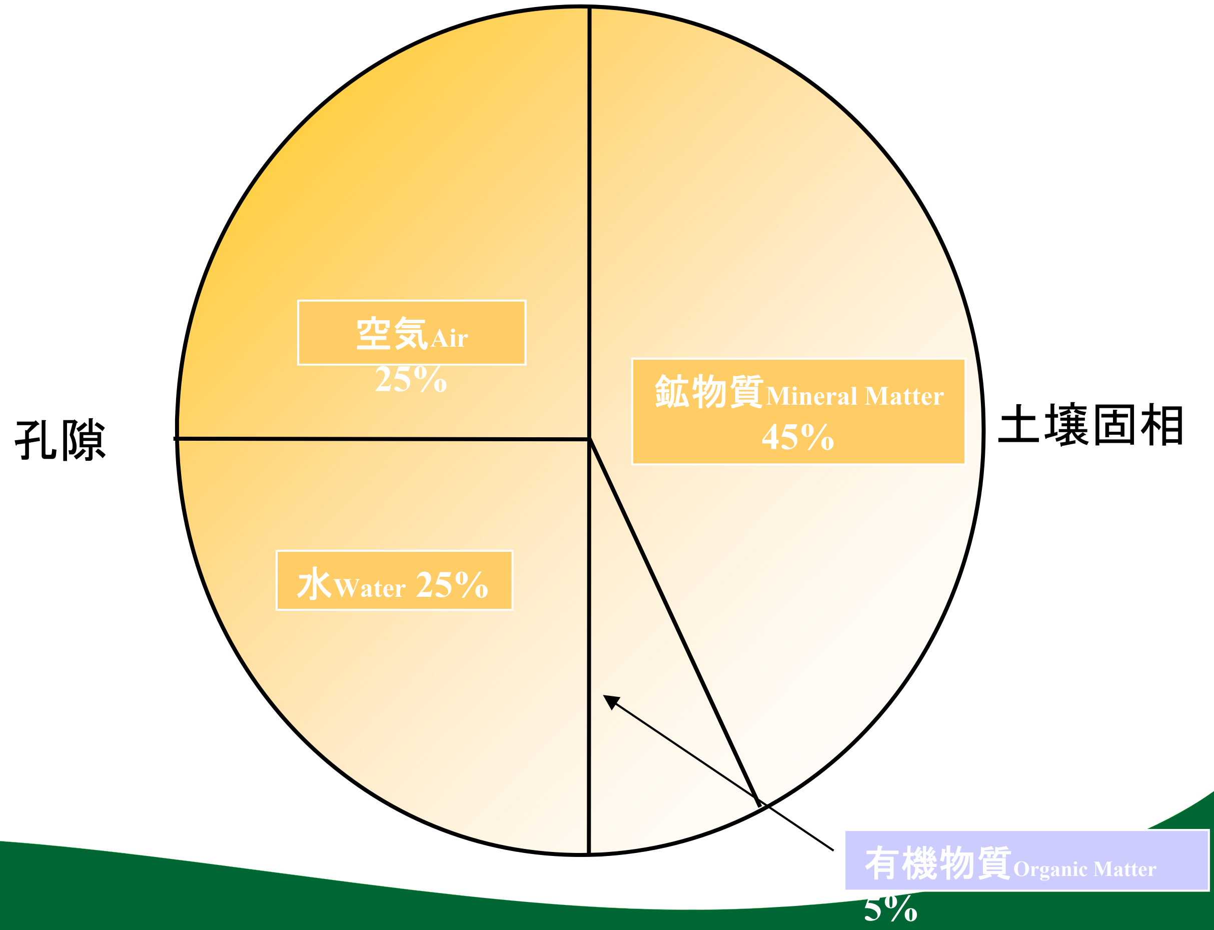
養分･イオン･塩･pH･CEC

粒度･透水･硬度･形状

Simplot

土壌の構成物質（三相組成）

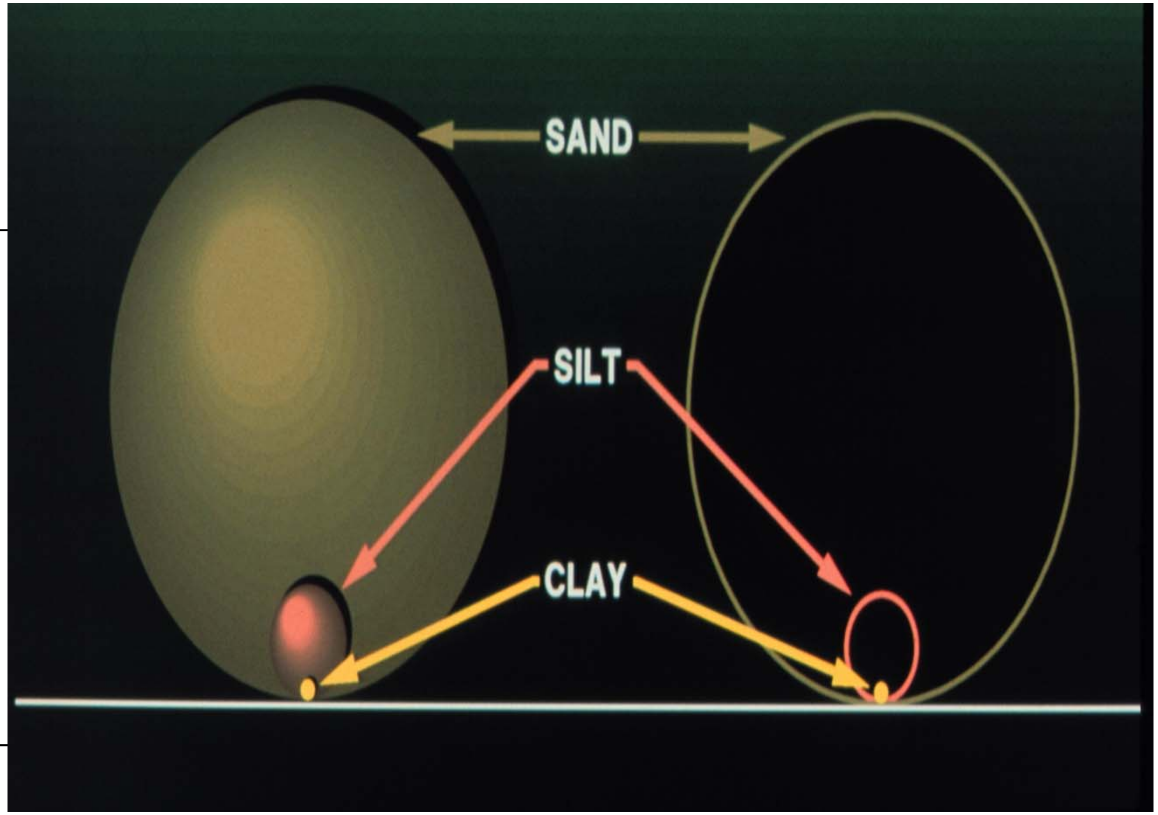
- 無機物
- 有機物
- 空気
- 水



Simplot

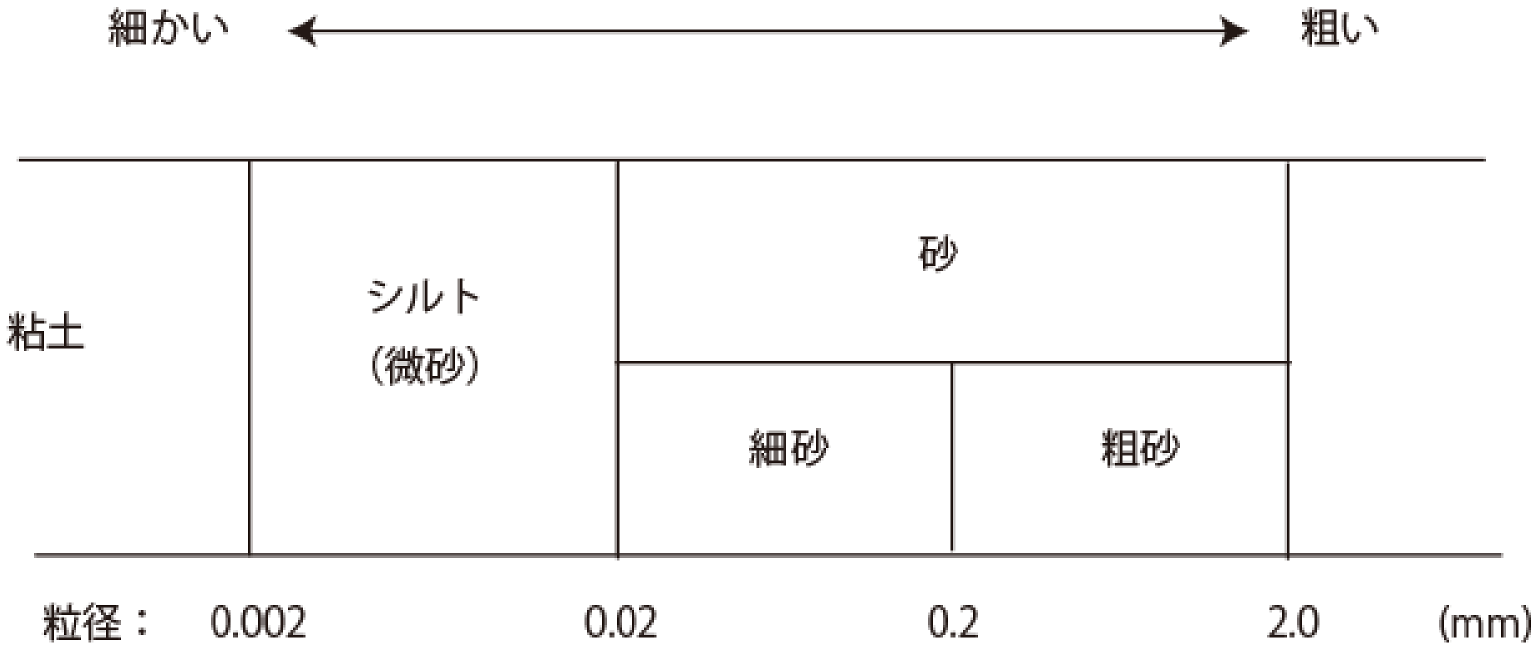
3つの鉱物質の部分

- 砂
- シルト
- 粘土



Simplot

土壌の粒径区分



国際法による土壌の粒径区分

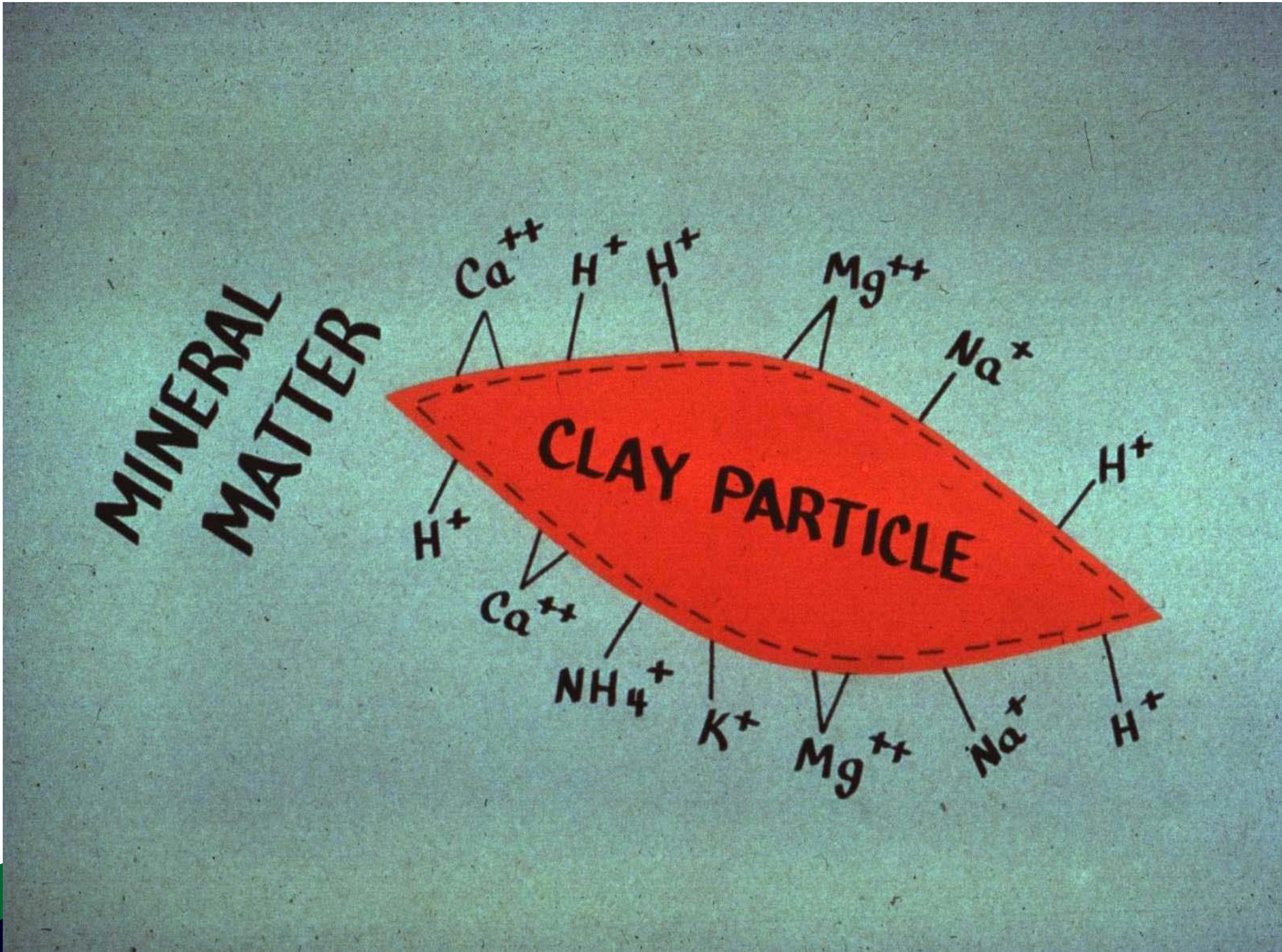
土壌粒子の大きさ

土壌粒子	粒子の径	比較類推
大変粗い砂	2.00-1.00	直径2.4mの玉
粗い砂	1.00-0.50	直径1.2mの玉
中粗砂	0.50-0.25	直径0.6mの玉
細かい砂	0.25-0.10	バスケットボール
大変細かい砂	0.10-0.05	ソフトボール
シルト	0.05-0.002	ゴルフボール
粘土	0.002	ポップコーンの種

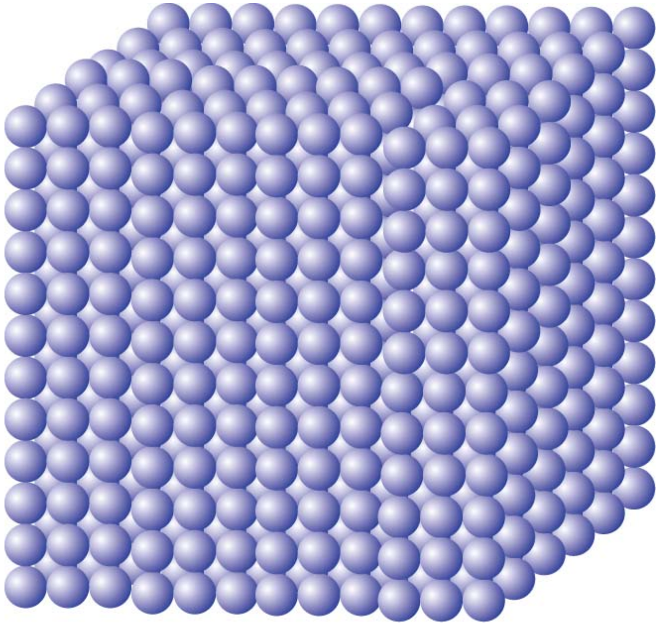
土壌粒子

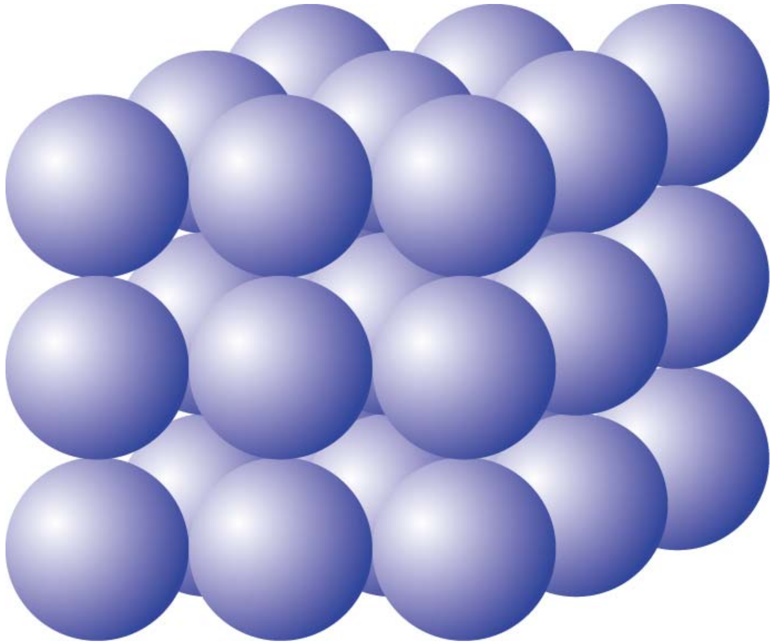
国際土壌学会法

粒径区分	直径(mm)	1g当たり粒子数	1g当たり表面積(cm^2)
粗砂	2.00-0.20	720	23
細砂	0.20-0.02	46,000	91
シルト	0.02-0.002	5,776,000	454
粘土	0.002以下	90,260,853,000	8,000,000（800m^2）


MINERAL MATTER
CLAY PARTICLE
Ca++
H+
H+
Mg++
Na+
H+
H+
Ca++
NH4+
K+
Mg++
Na+
H+

土壌粒子の総表面積





CEC（陽イオン交換容量）

CEC	土壌の種類
0 - 8	砂
8 - 12	砂壌土
13 - 20	シルト壌土
21 - 28	壌土
29 - 40	粘土壌土
> 40	粘土

Simplot

土性区分

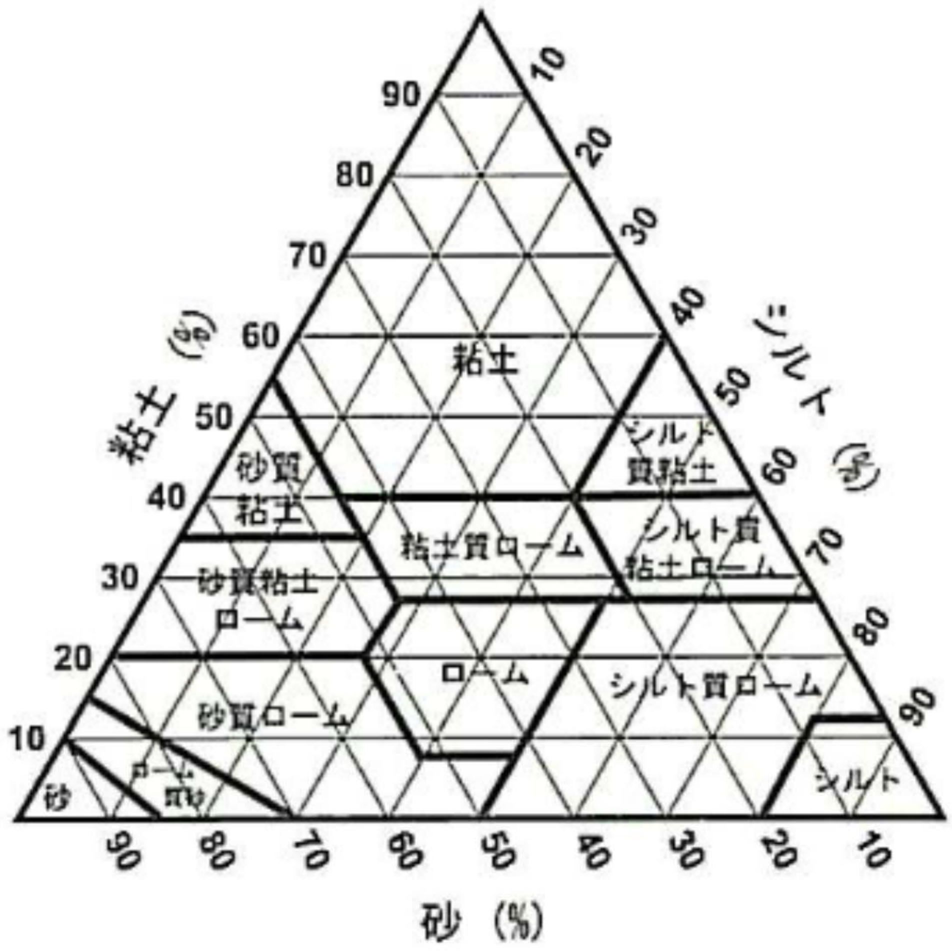
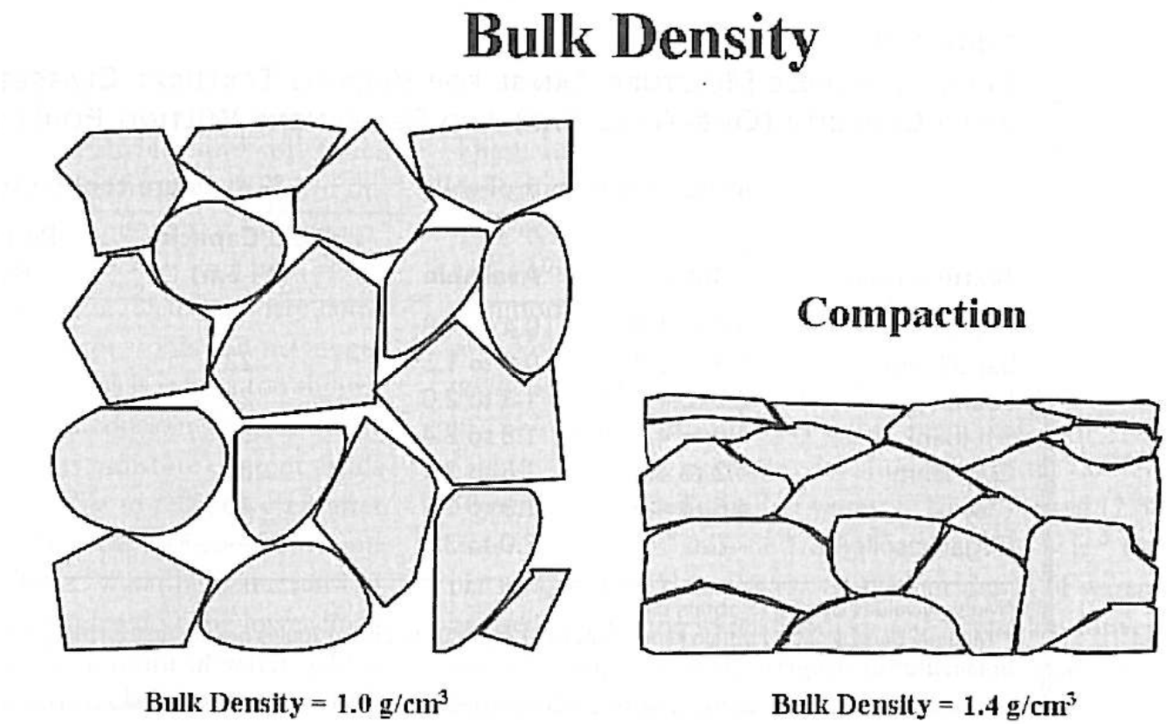


図 1.2　土性を構成する砂，シルト，粘土の含有量を示す 3 角図.

仮比重



Bulk Density
Compaction
Bulk Density = 1.0 g/cm³
Bulk Density = 1.4 g/cm³

仮比重

- 孔隙率を求める
- 砂の比重＝2.6～2.75g/cc
- 有機物の比重＝0.2～1.0g/cc
- 仮比重＝乾燥土壌(g)÷土壌総容積(cc)
- クレイ･クレイローム･シルト＝1.0～1.6g/cc
- 砂･サンディローム＝1.2～1.8g/cc

仮比重･孔隙率

- サンドグリーンの場合

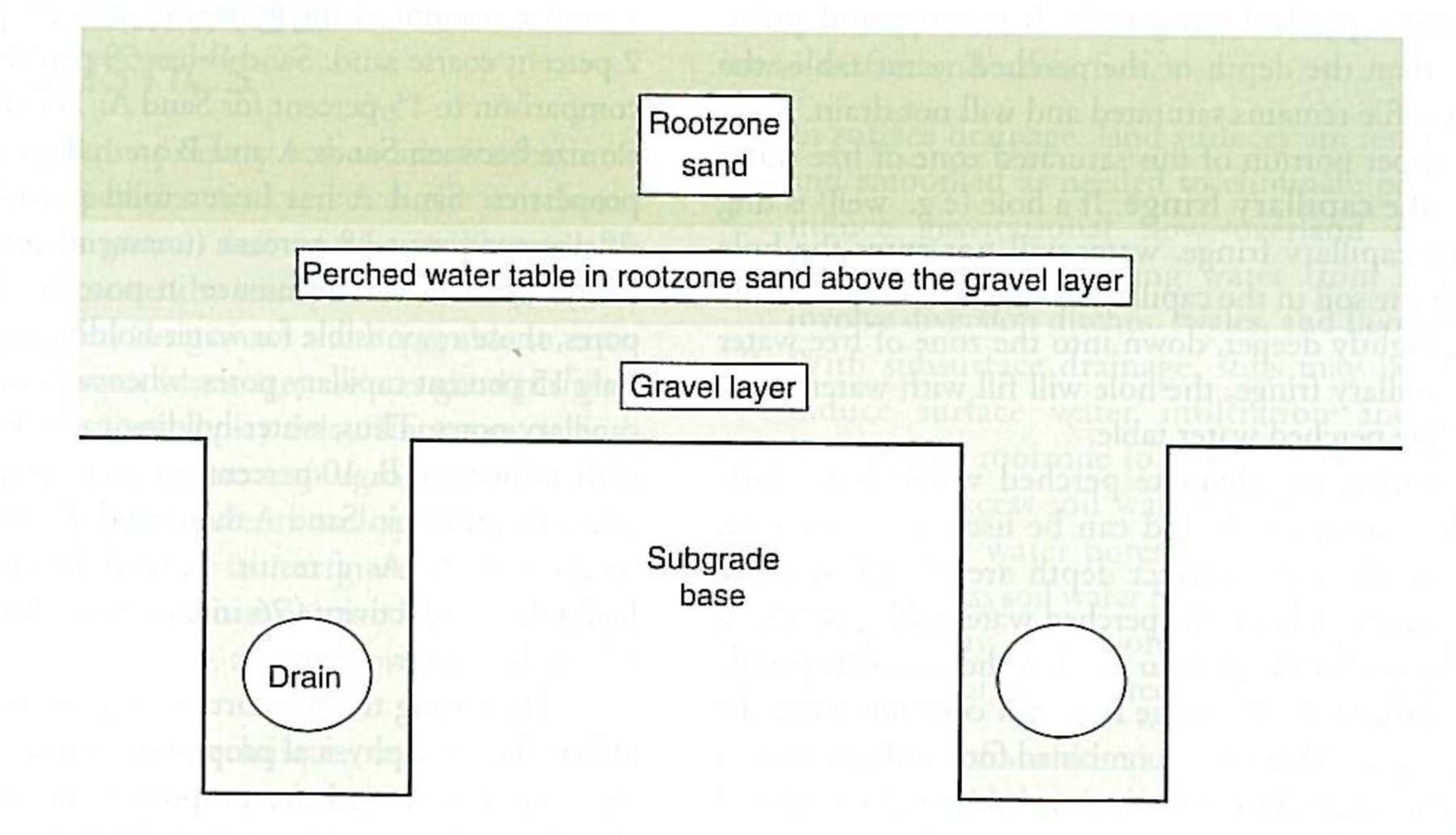
- 仮比重は1.25～1.55g/cc
- 理想は1.40g/cc

- 孔隙率（%）＝（仮比重/粒子比重）x100

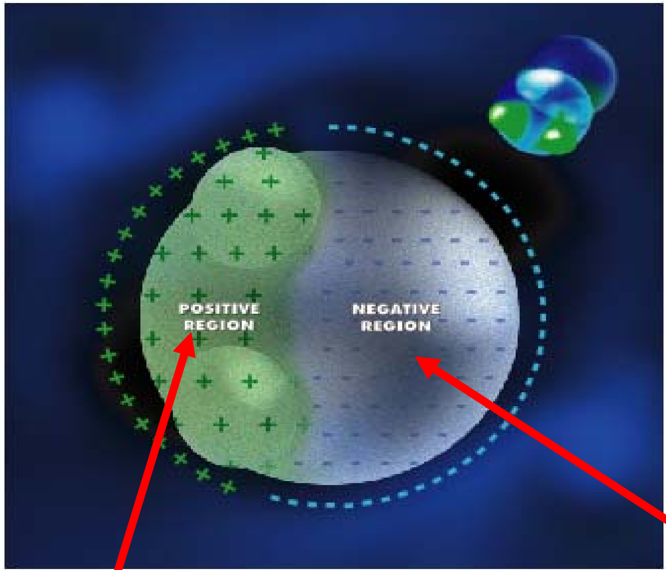
グリーンの砂

	粒子サイズ	USGA方式		カルフォルニア方式
	mm	%		
粘土	<0.002	<3	<10	0-8
シルト	0.002-0.05	<5		
微細砂	0.05-0.15	<5		
細砂	0.15-0.25	<20		82-100
中砂	0.25-0.5	<35(75)	<60	
荒砂	0.5-1.0	<45		
大荒砂	1.0-2.0	<7	<10	0-10
砂利	>2	<3		

グリーンの構造


Rootzone sand
Perched water table in rootzone sand above the gravel layer
Gravel layer
Subgrade base
Drain

水分子
THE WATER MOLECULE



水分子は

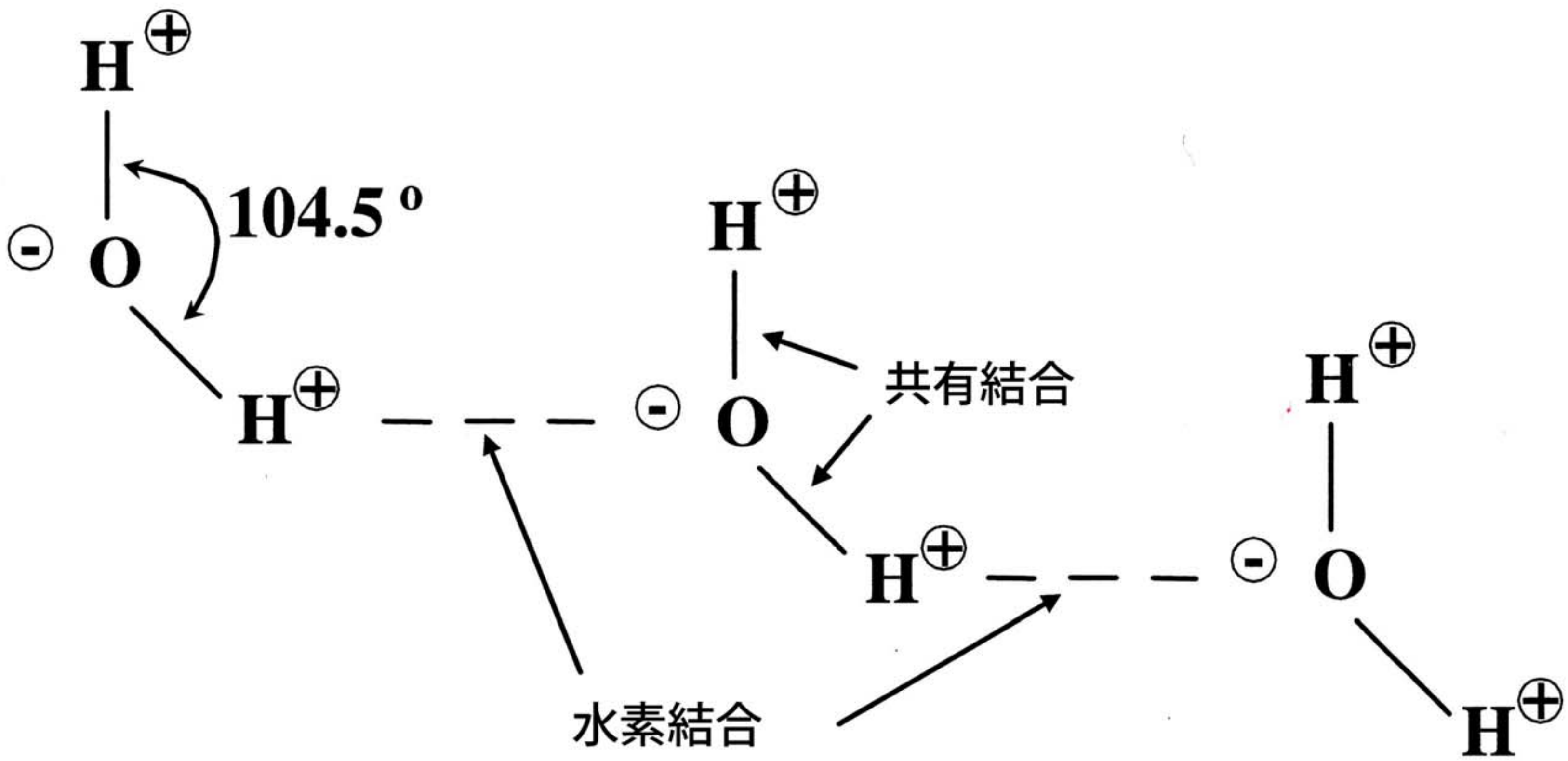
双極

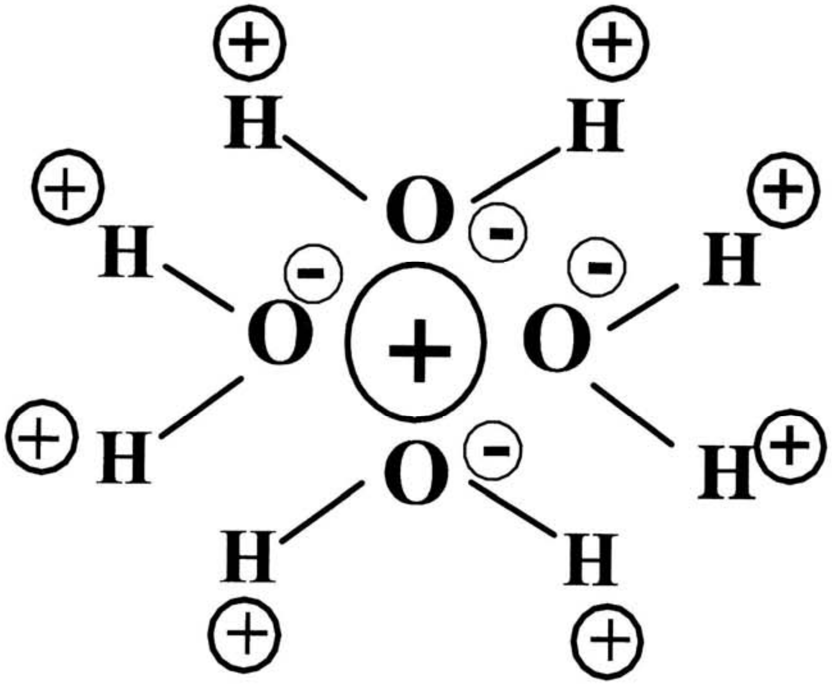
THE WATER MOLECULE IS

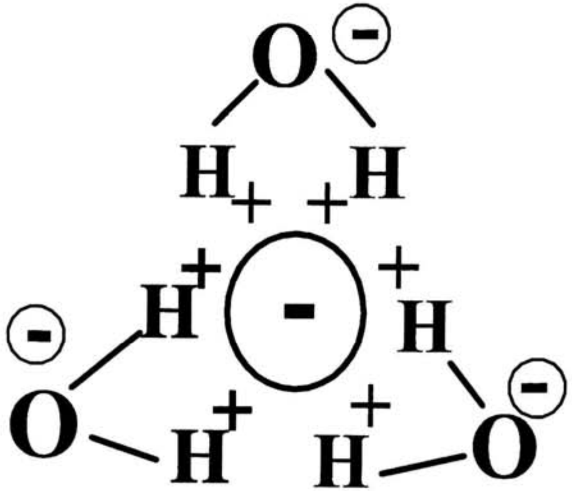
DIPOLAR

酸素側～マイナス極
The Oxygen end – Negative Potential

水素側～プラス極
The Hydrogen End – Positive Potential


H
104.5 °
O
H
O
H
共有結合
H
H
O
水素結合
H

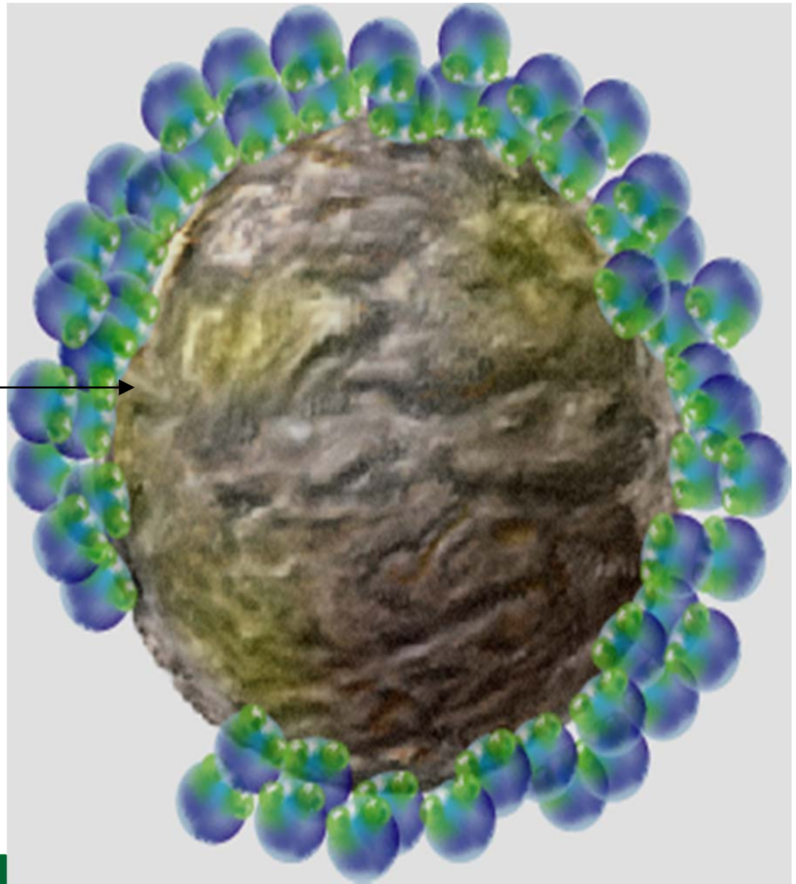




利用可能な水
Water Availability

からからの乾燥
Oven Dry

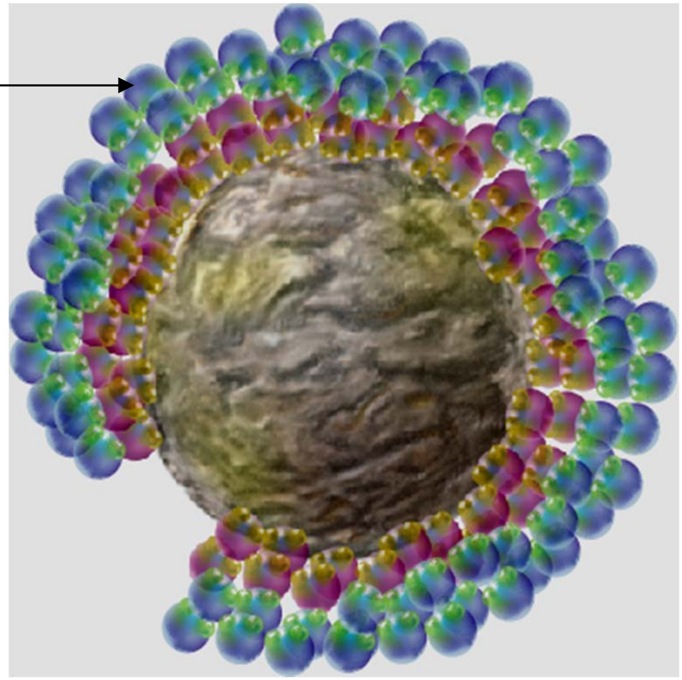
利用可能な水
Water Availability



湿りやすい共同因子
Hygroscopic Coefficient

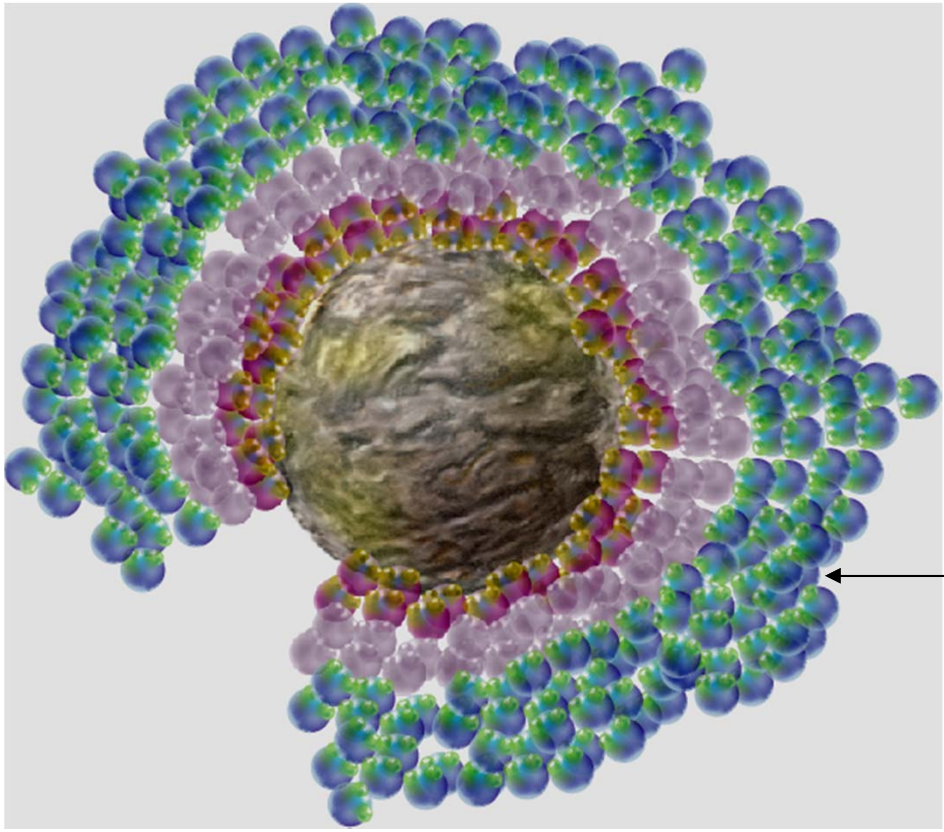
利用可能な水
Water Availability

弱る部分
Wilting Point



利用可能な水

Water Availability



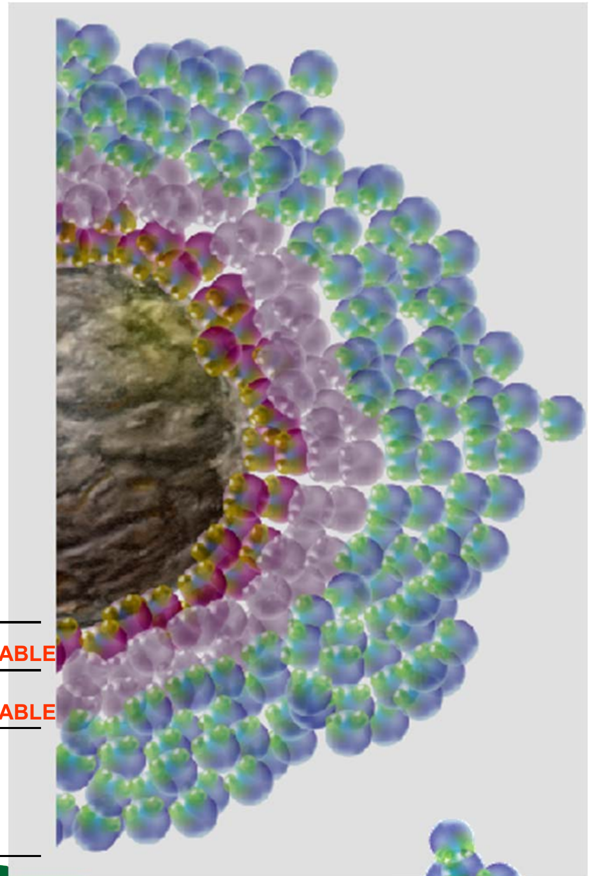
抱え込む領域
Field Capacity

重力作用水
Gravitational Water

利用可能な水

Water Availability

張力（バール）Tension (bar)



カラカラの乾燥Oven Dry (-10,000)

利用不可NOT AVAILABLE

湿りやすい共同因子Hygroscopic Coefficient (-31)

利用不可NOT AVAILABLE

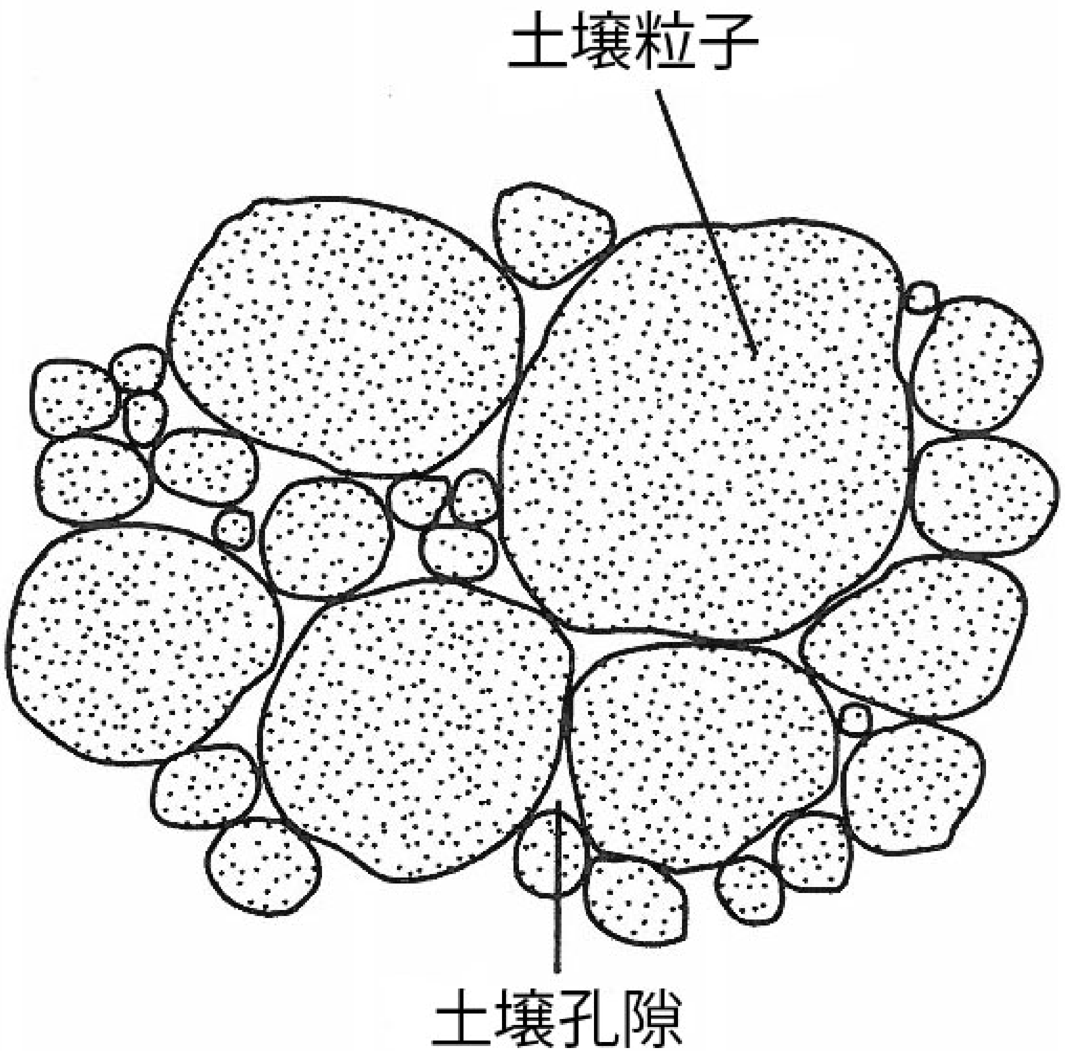
弱る部分Wilting Point (-15)

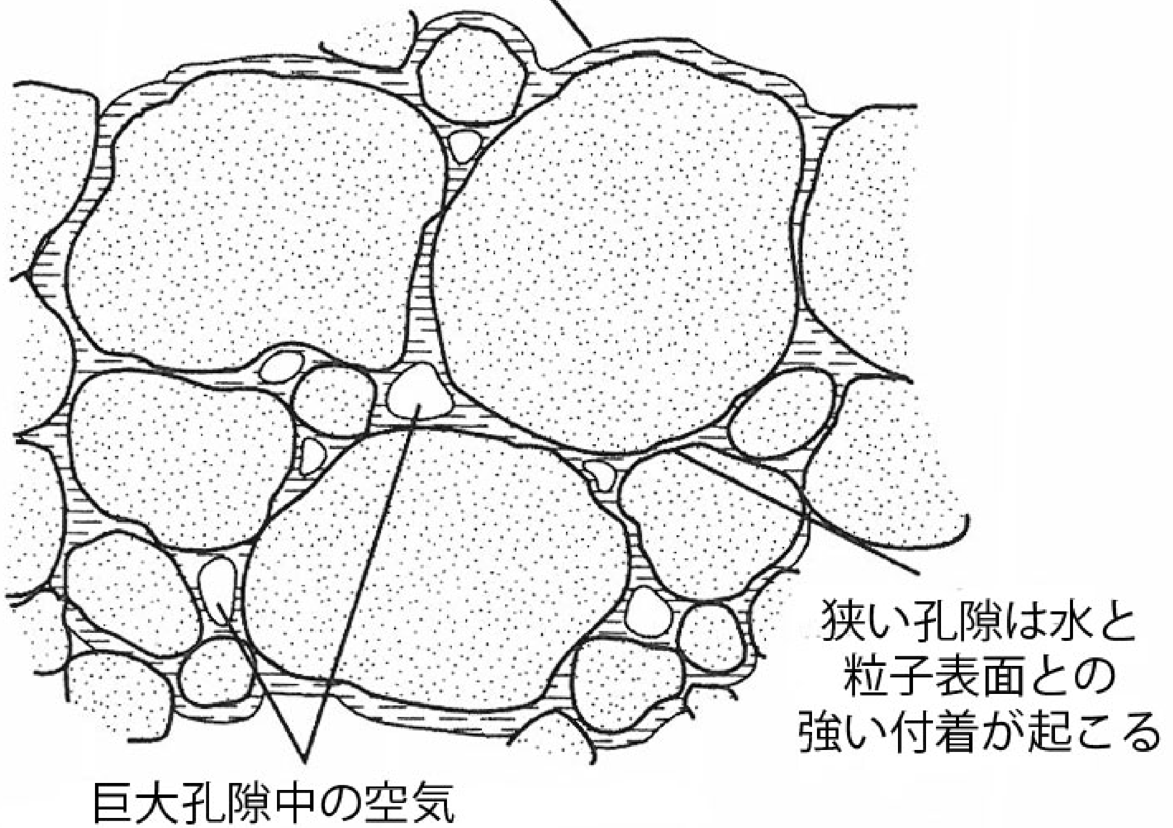
利用可能水
AVAILABLE WATER

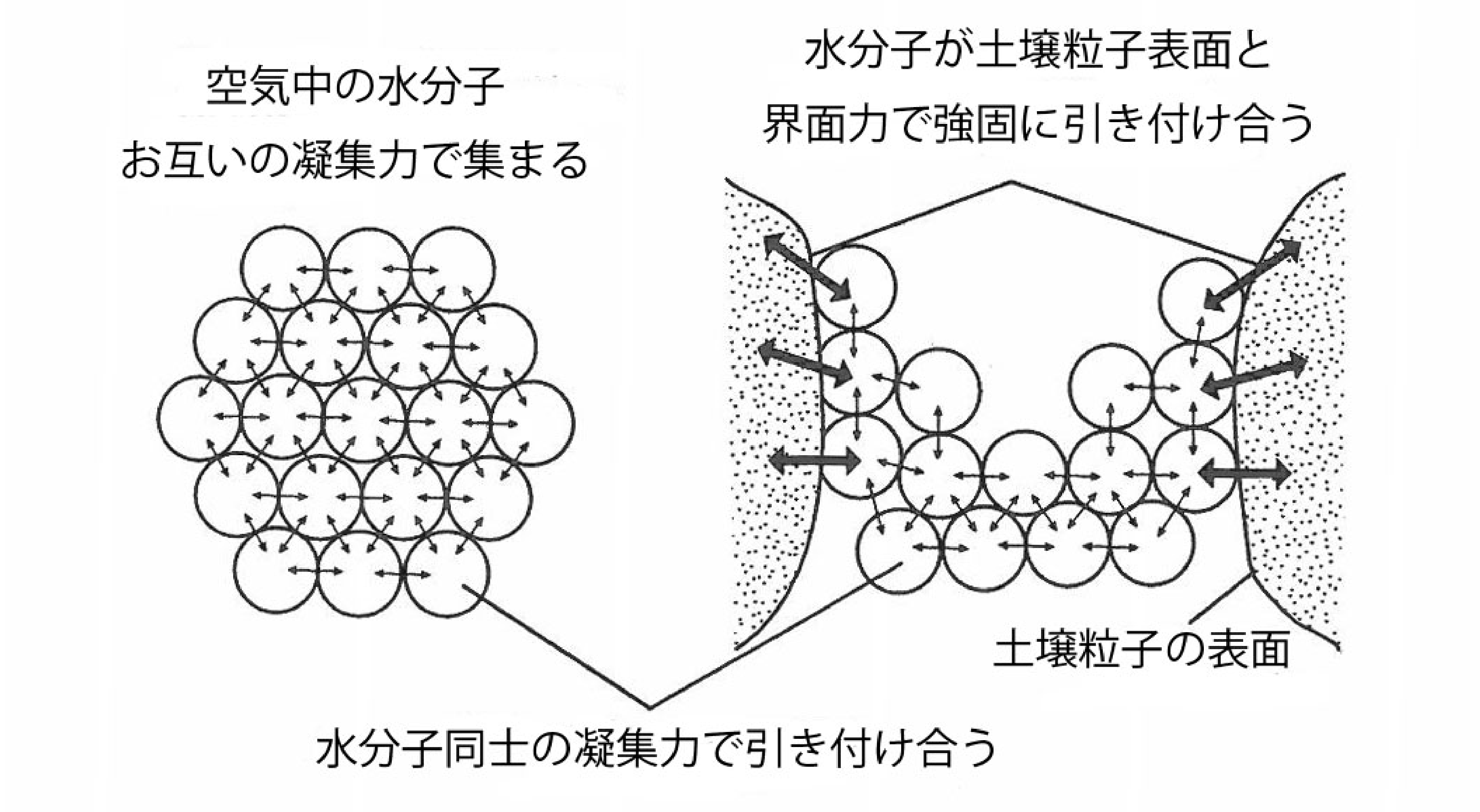
抱え込む領域Field Capacity (-0.3)

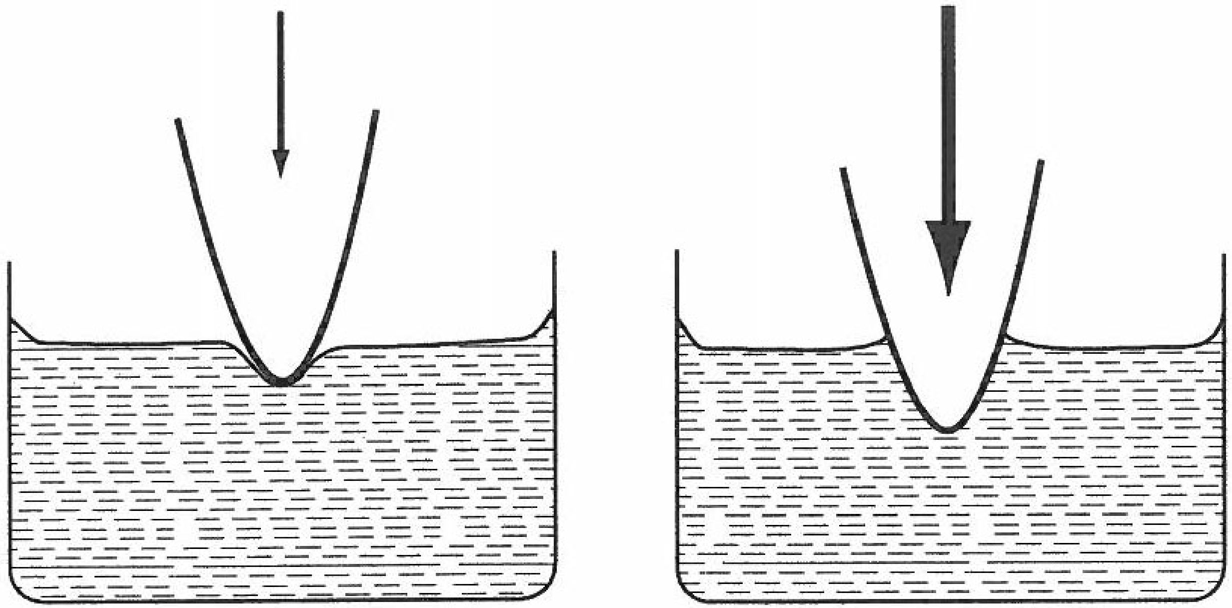
利用不可NOT AVAILABLE

重力作用水Gravitational Water (>0.3)


土壤粒子
土壤孔隙


重力に反して表面張力の力で
土壌粒子の表面に付着する水
狭い孔隙は水と
粒子表面との
強い付着が起こる
巨大孔隙中の空気

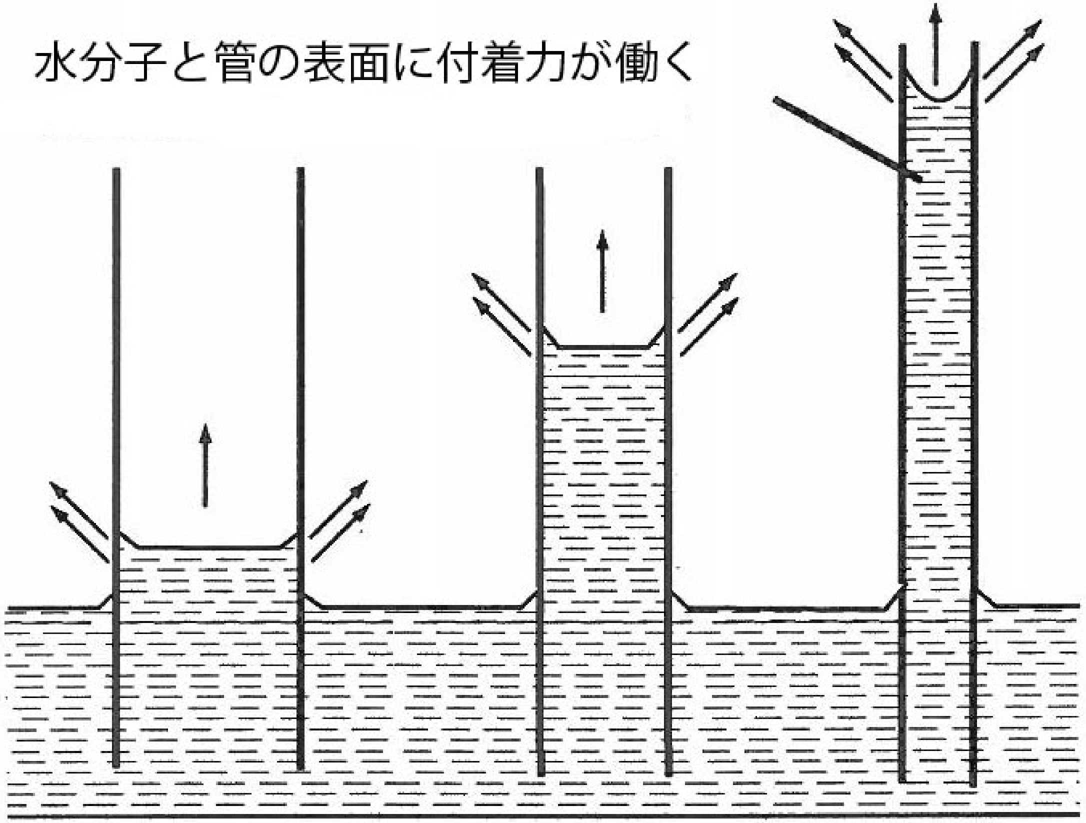

空気中の水分子
お互いの凝集力で集まる
水分子が土壌粒子表面と
界面力で強固に引き付け合う
土壌粒子の表面
水分子同士の凝集力で引き付け合う



緩やかな力で
表面張力を押さえる

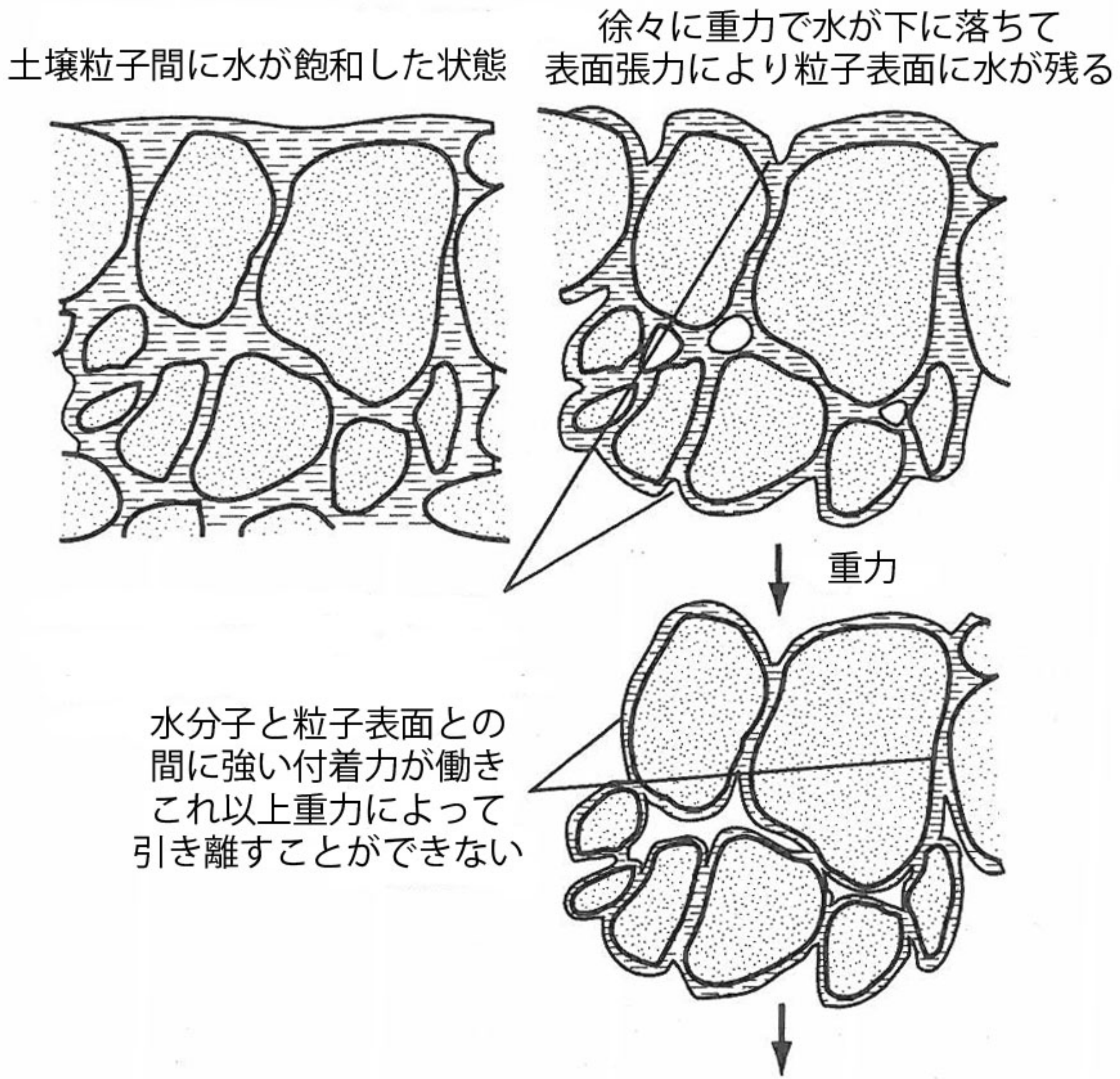
強い力で表面張力を
破る

水分子と管の表面に付着力が働く

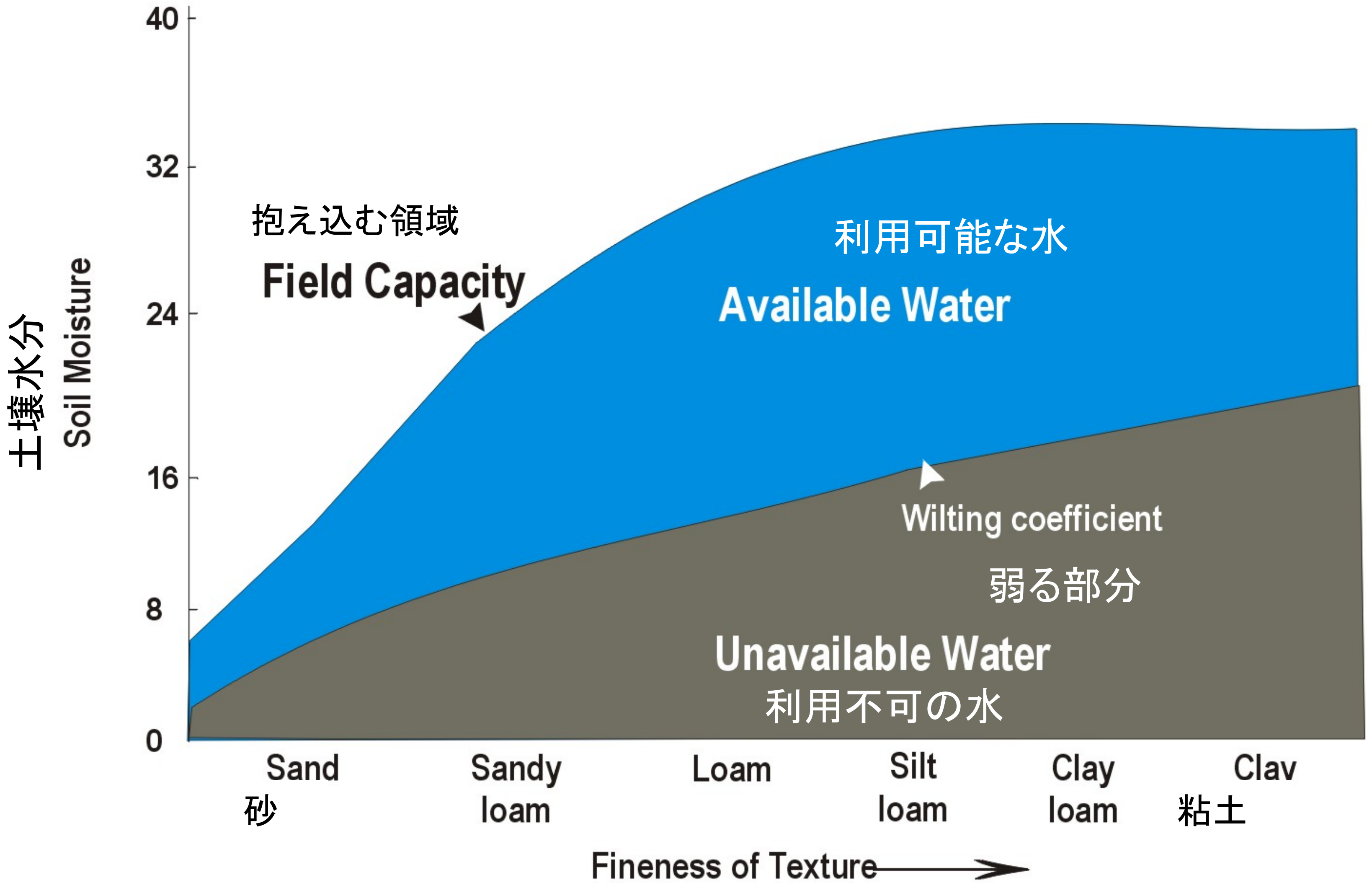


付着力によって重力に反して上に向かって水が移動する

毛細管現象


土壌粒子間に水が飽和した状態
徐々に重力で水が下に落ちて
表面張力により粒子表面に水が残る
重力
水分子と粒子表面との
間に強い付着力が働き
これ以上重力によって
引き離すことができない

Simplot



きめ細かくなる

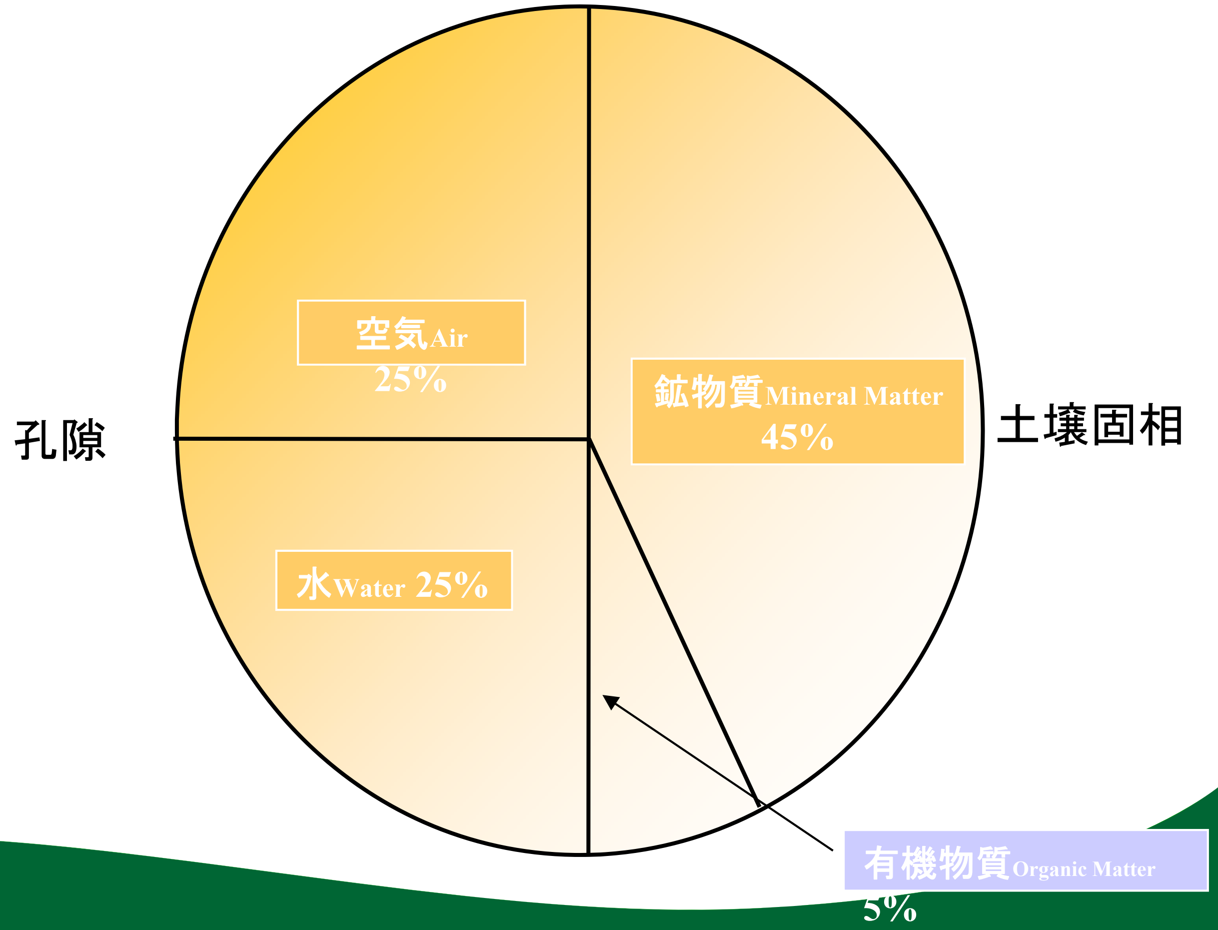
Simplot

土壌水分の重要性

- 空気の層は根の成長に不可欠
- 空気の層は土壌表面の温度を伝えにくい
- 散水の基本は『多量・小回数』
- しおれ点（８％）
- 最大２５％
- 長雨による飽和からの空気層の回復

土壌の構成物質(三相組成)

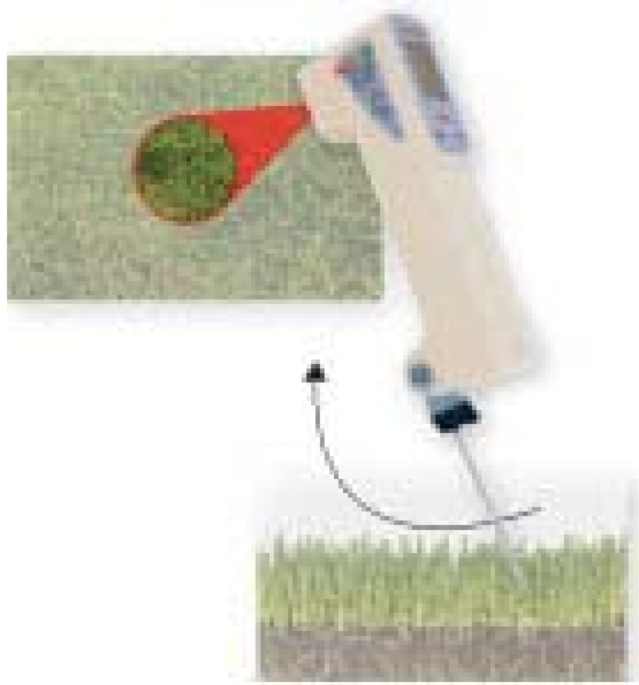
- 無機物
- 有機物
- 空気
- 水



土壤水分計

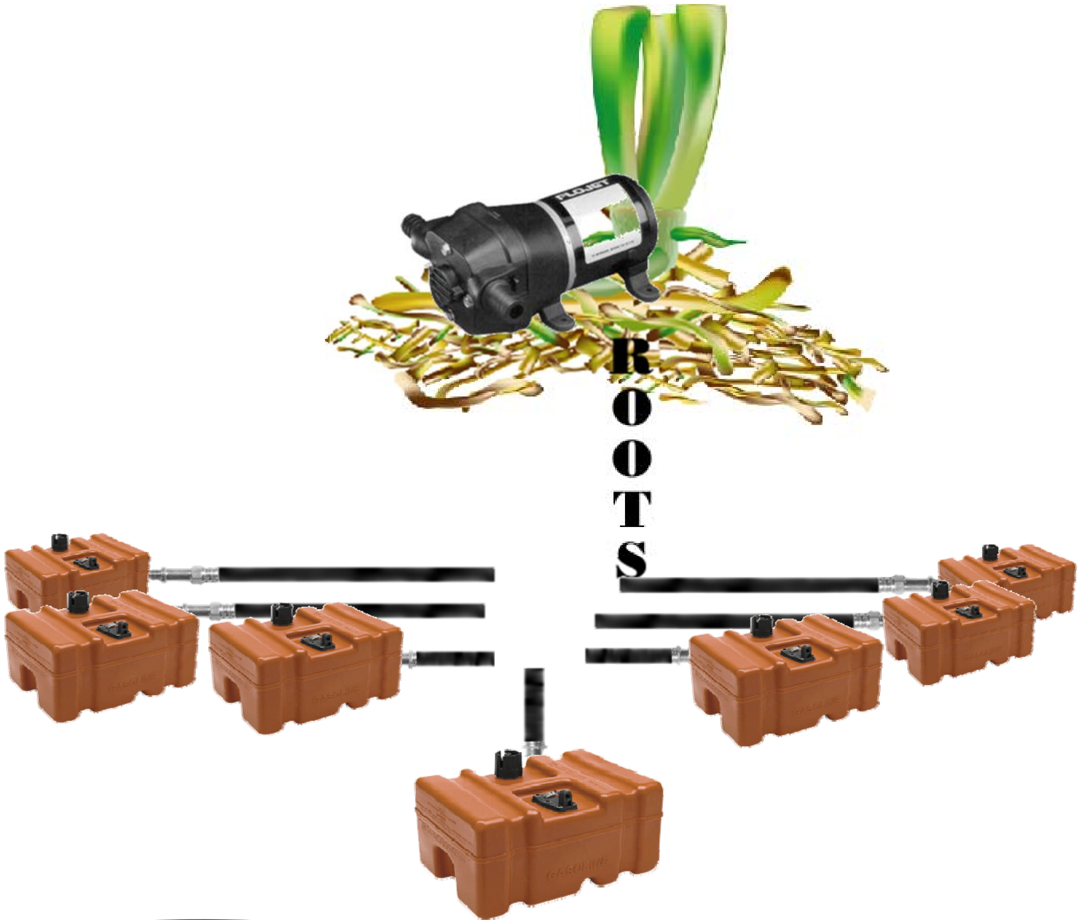

FIELDSCOUT
TDR 100
ON
MODE
Delete
Clr Avg
READ
Spectrum
Technologies, Inc.

赤外線・土壌温度計



水の必要性について考えてみましょう

Meeting the Water Requirements



良い根は燃料パイプのように働きます

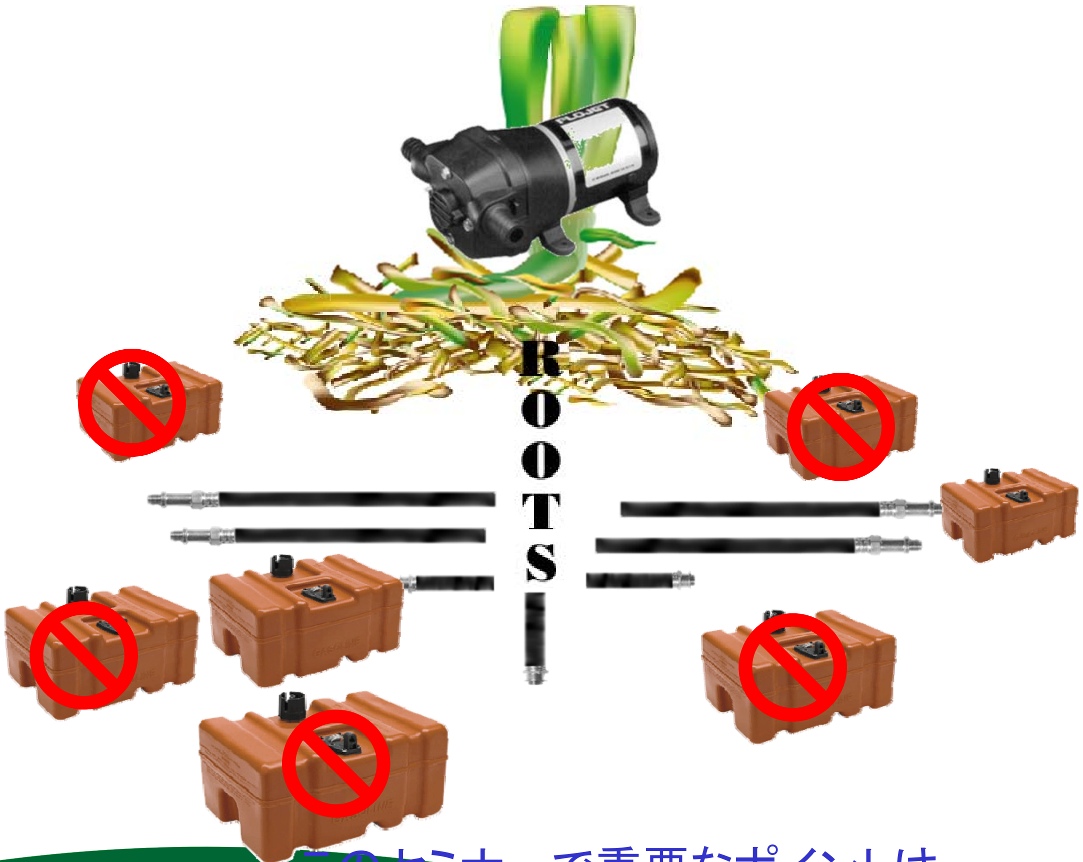
Lateral fine roots act like fuel lines…

水の貯水池（燃料タンク）は土壌層です

To water reservoirs (fuel tanks) in the soil profile

水の必要性について考えてみましょう

Meeting the Water Requirements



このセミナーで重要なポイントは

A KEY POINT TO REMEMBER DURING THIS SEMINAR

水が根を捕まえなければいけないということ

WATER MUST INTERCEPT ROOTS

根は水を捕まえないということ

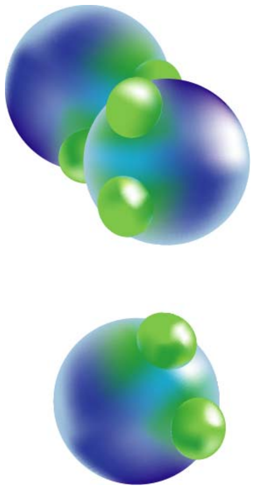
ROOTS DON'T INTERCEPT WATER

撥水を考える

UNDERSTANDING WATER REPELLENCY

水のサッチと土壌層との関連

WATER'S' RELATIONSHIP TO THATCH & SOIL PROFILE

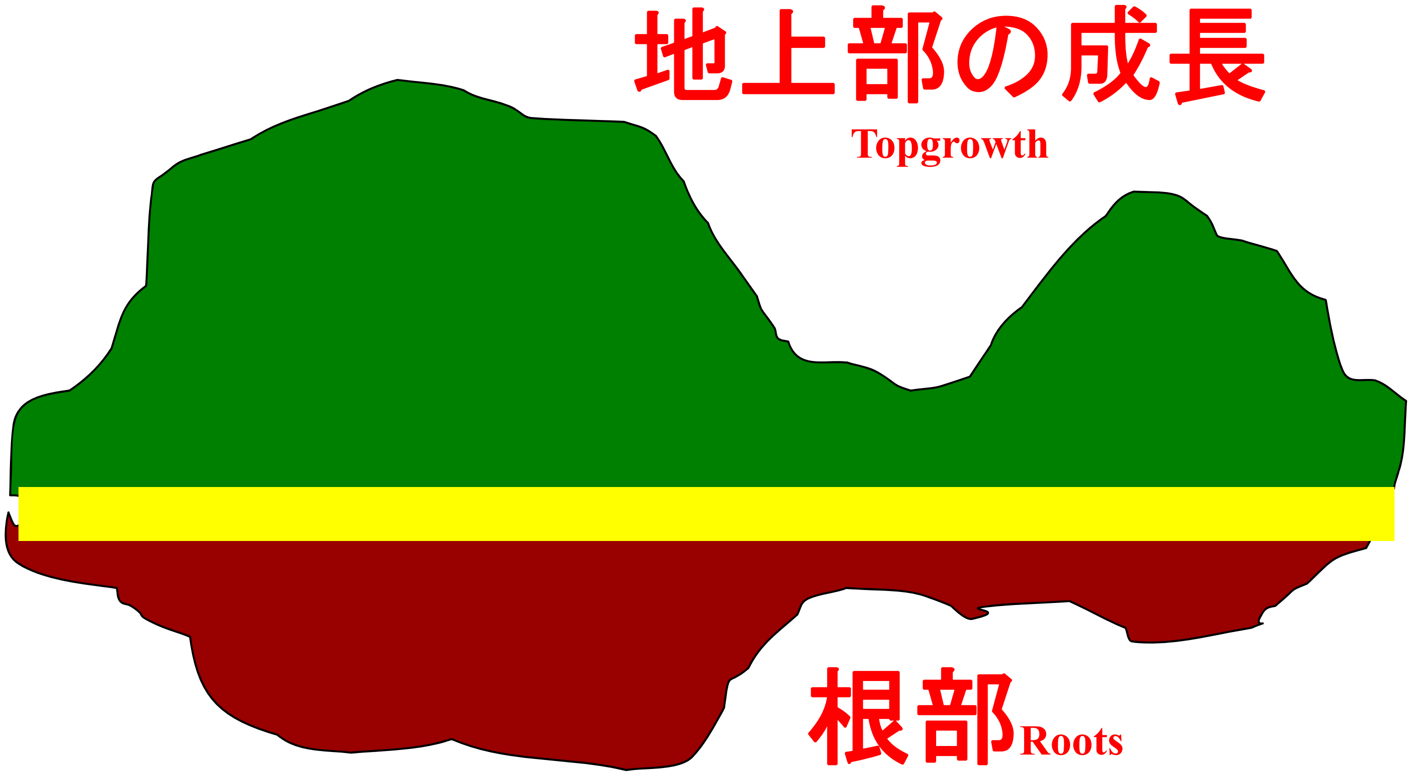


水分子

WATER MOLECULES

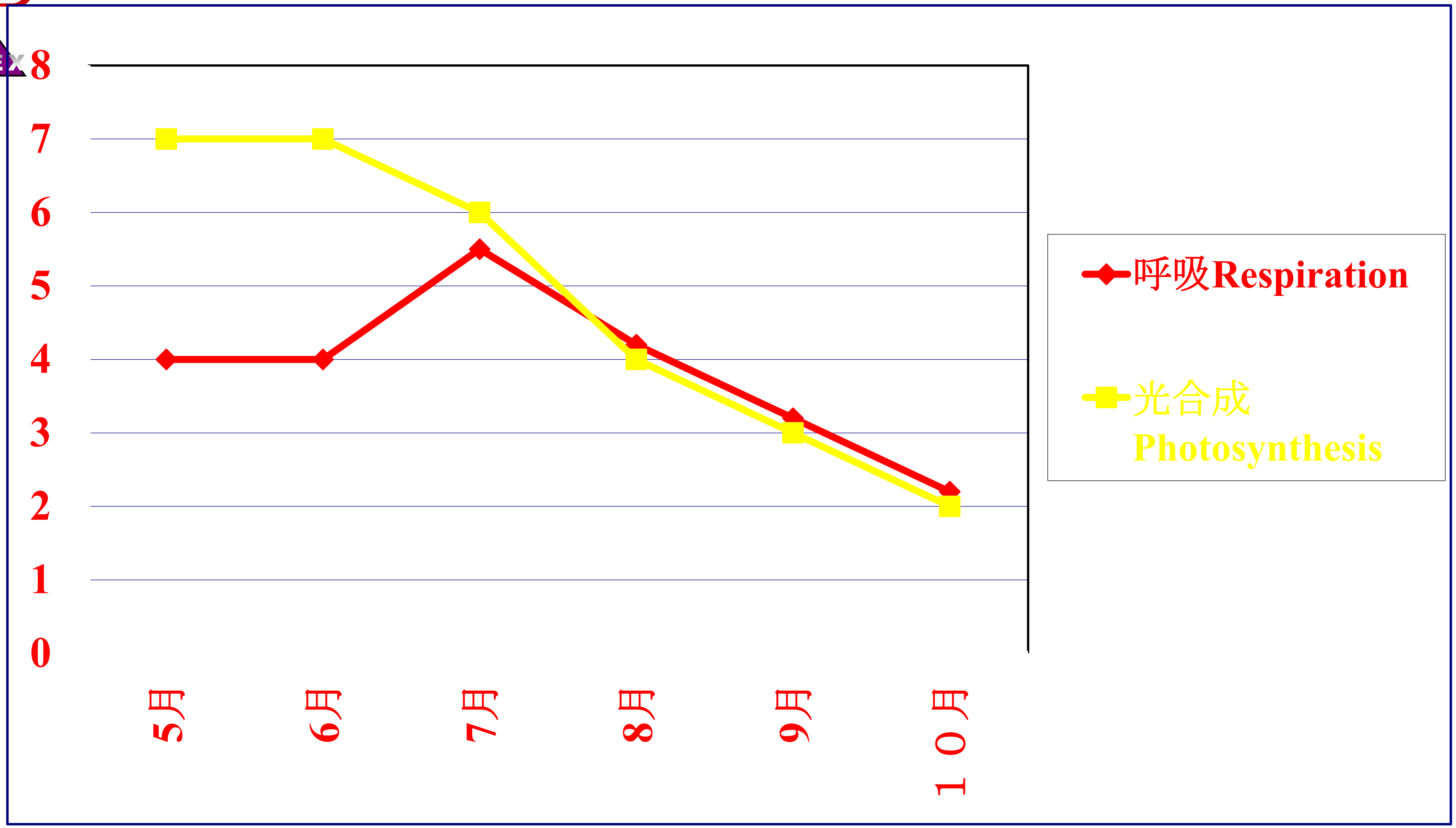
サッチと土壌層

THATCH & SOIL PROFILE



芝生の根部と地上部の成長の季節変化
Seasonal patterns of root and shoot growth of turfgrass

刈高3.2mmの芝の7月と8月の呼吸が光合成を超えるIn July and August respiration exceeds photosynthesis in turf grass mowed at 1/8 inch

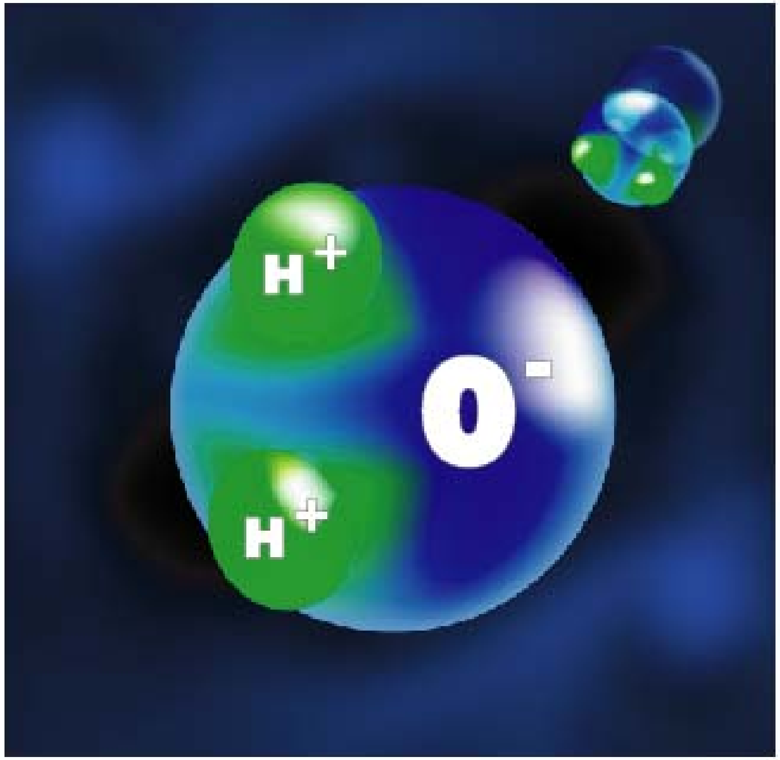


刈高4mmの芝の光合成と呼吸

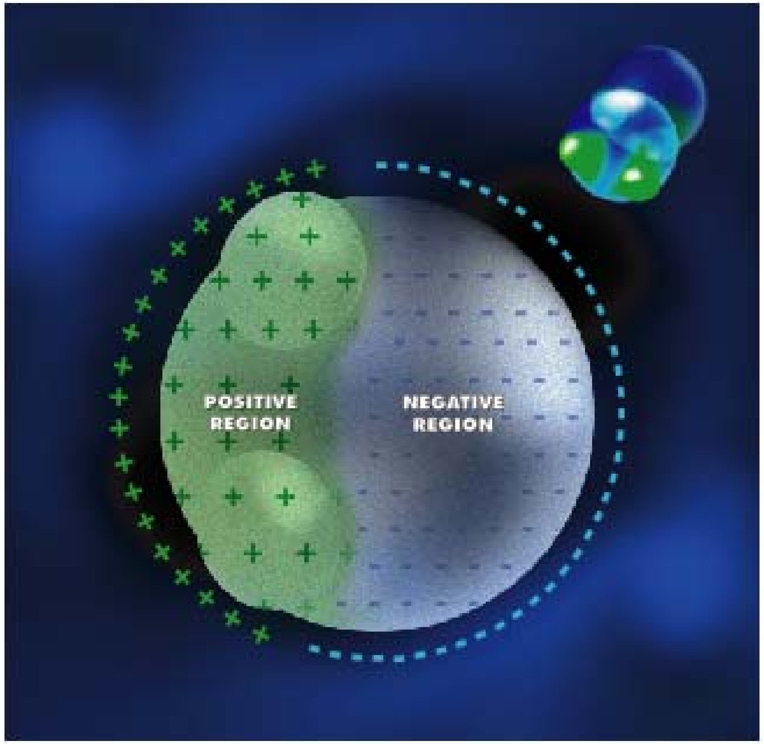
Photosynthesis and respiration in turf grass mowed at 5/32 inch

水分子

THE WATER MOLECULE



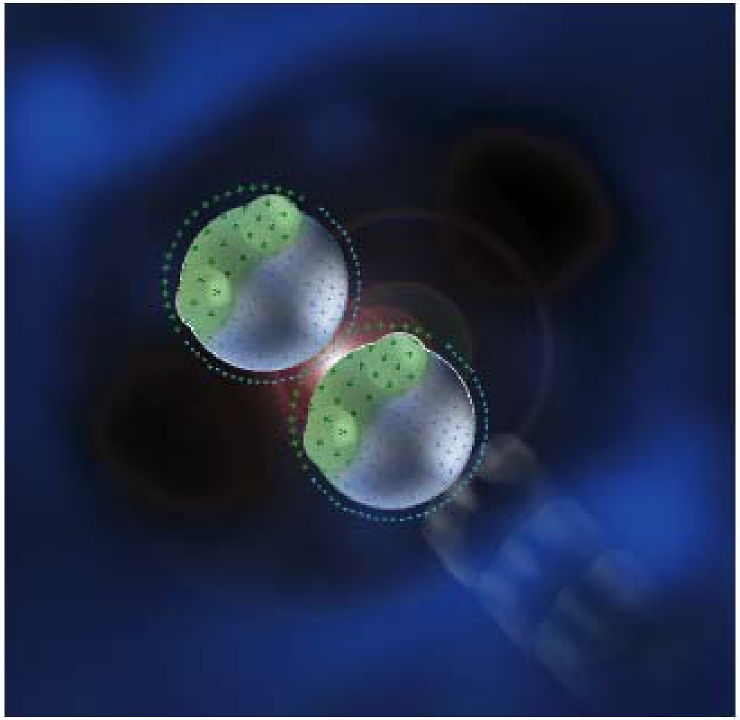
水分子
THE WATER MOLECULE



水分子＝双極
WATER MOLECULE = DIPOLAR

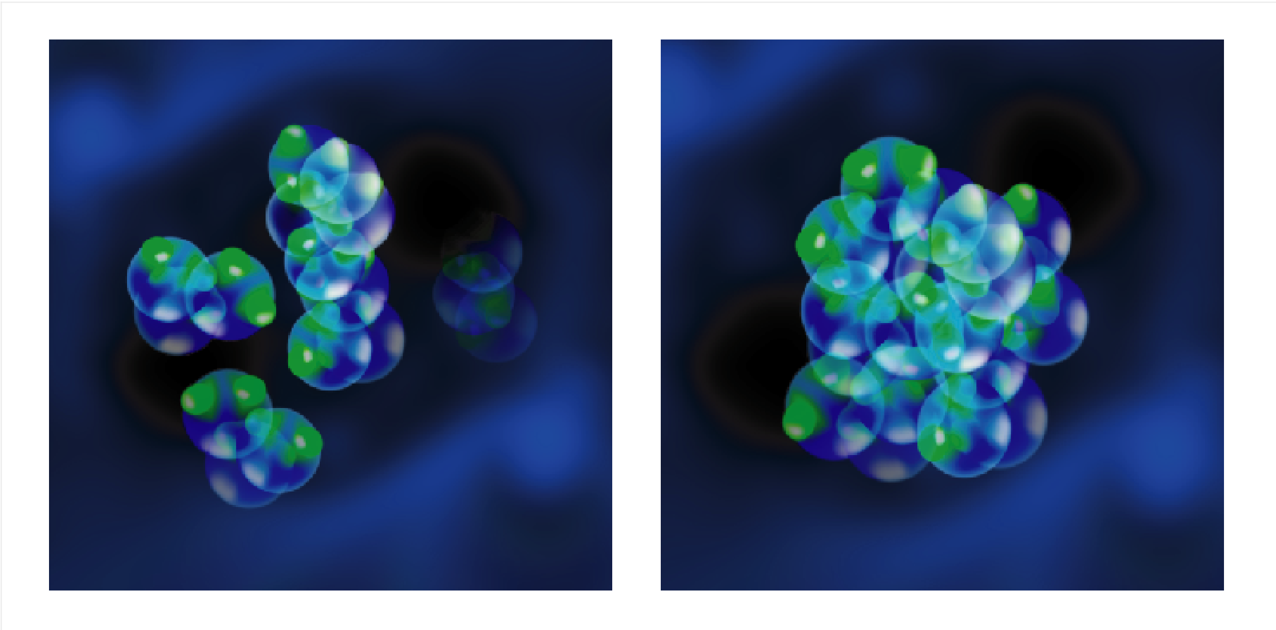
水分子の水素（プラス）側はマイナス側を引きつける（他の水分子の酸素側）

THE HYDROGEN (POSITIVE) END OF THE WATER MOLECULE IS ATTRACTED TO NEGATIVE SITES (INCLUDING THE OXYGEN END OF ANOTHER WATER MOLECULE)



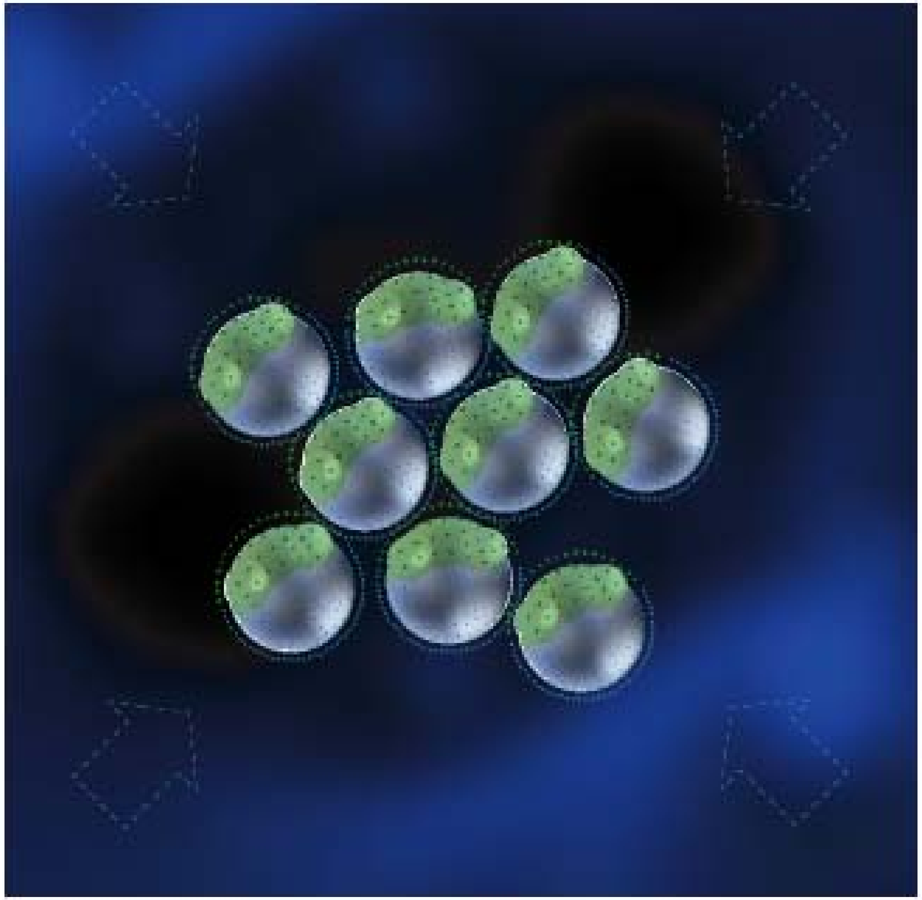
水素結合
HYDROGEN BOND

水分子はお互いに引きつけあいます
WATER MOLECULES ATTRACTED TO EACH OTHER

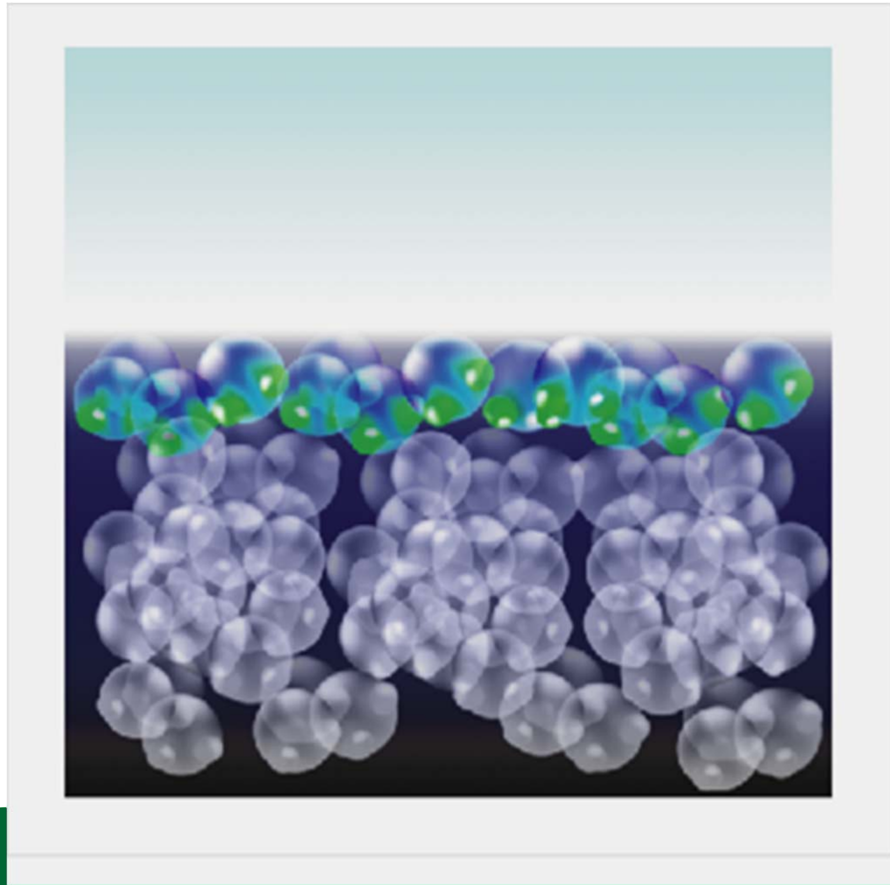


凝集
COHESION

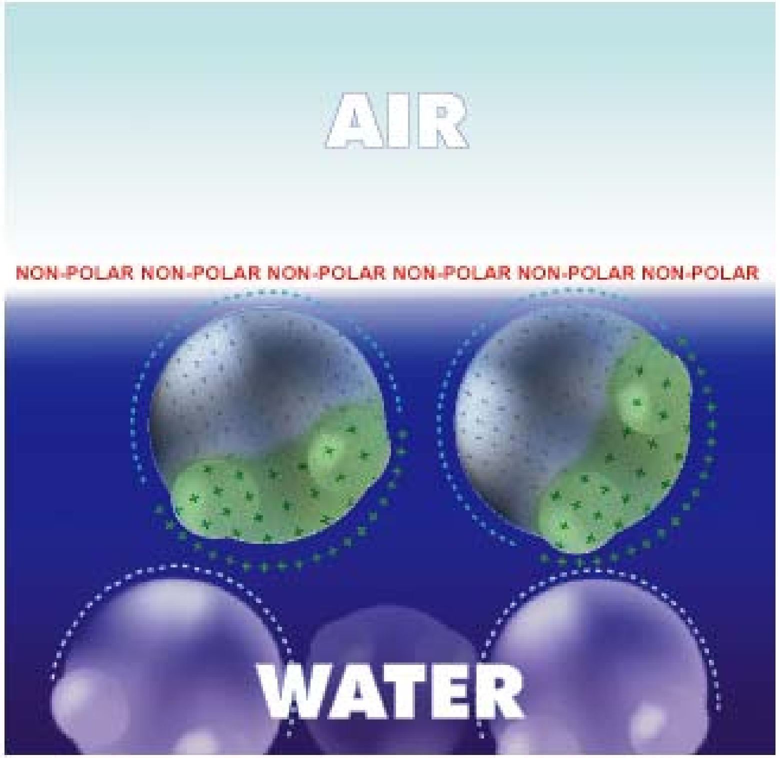
凝集
COHESION



ここで何が起こっているのでしょう？
WHAT'S HAPPENING HERE?

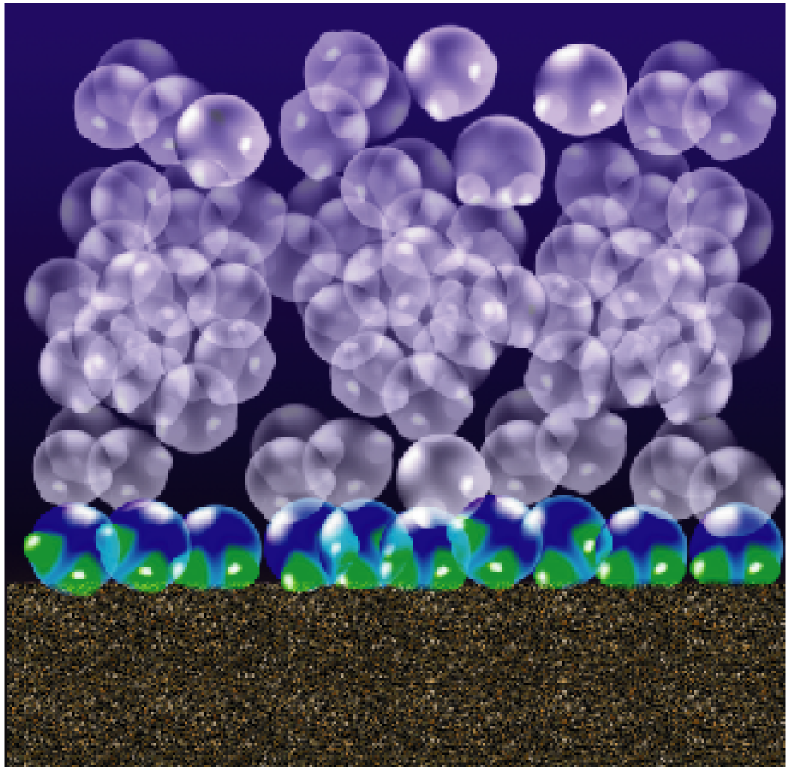


表面張力
SURFACE TENSION

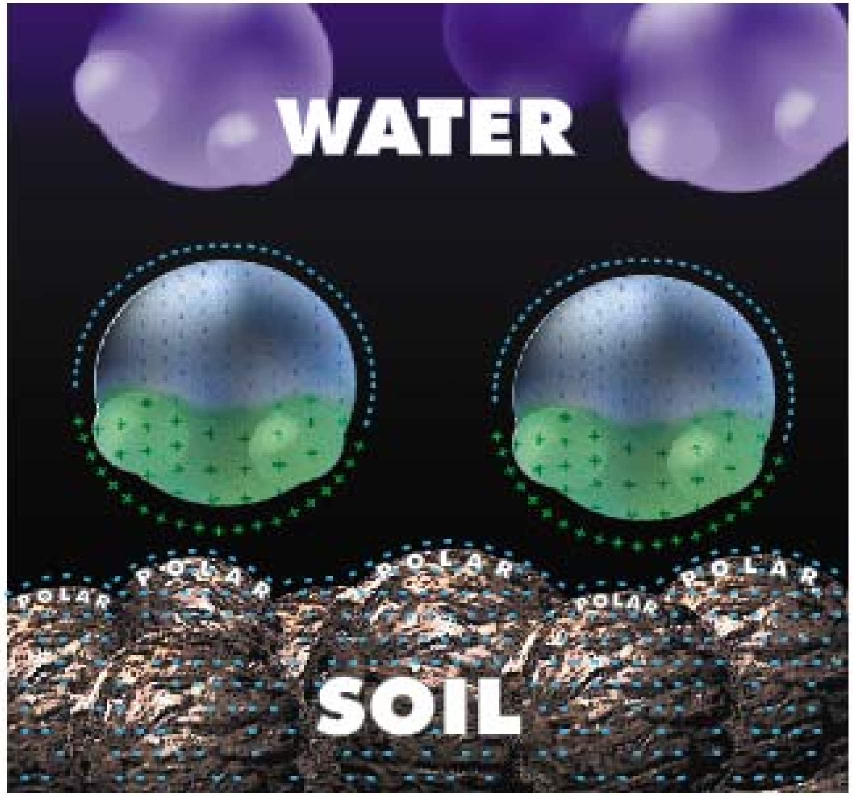


マイナスの土壌やサッチに水が引きつけられますか？

ATTRACTION OF WATER MOLECULES NEGATIVE SITES ON SOIL & THATCH?

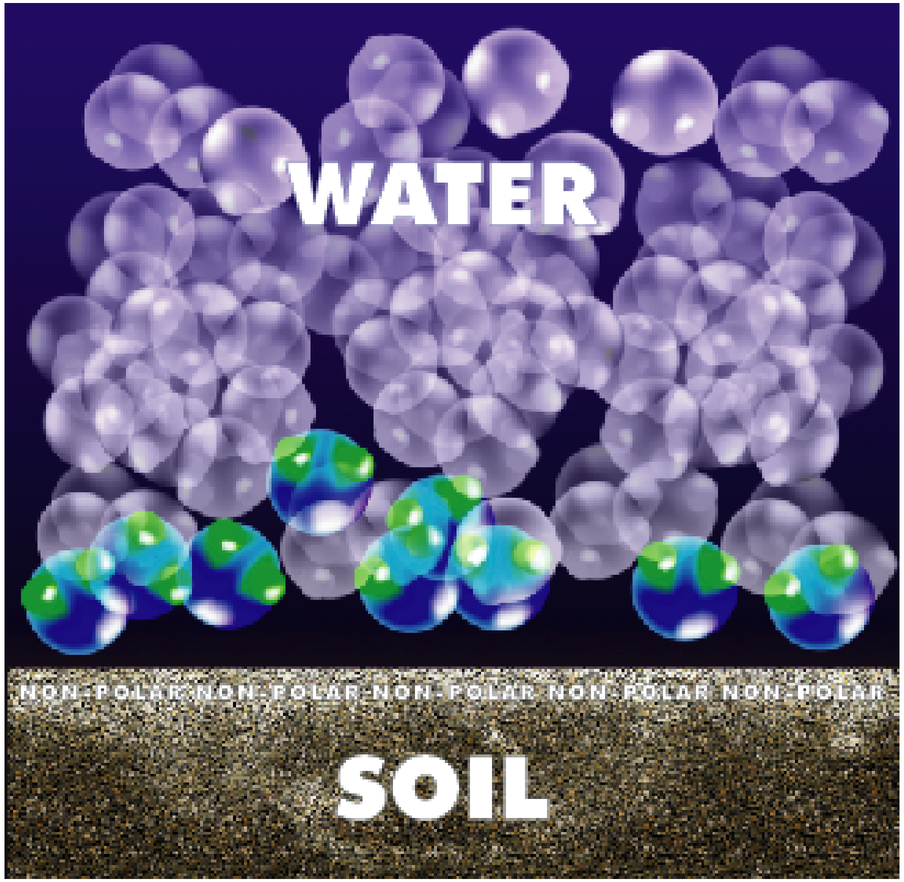


付着
ADHESION

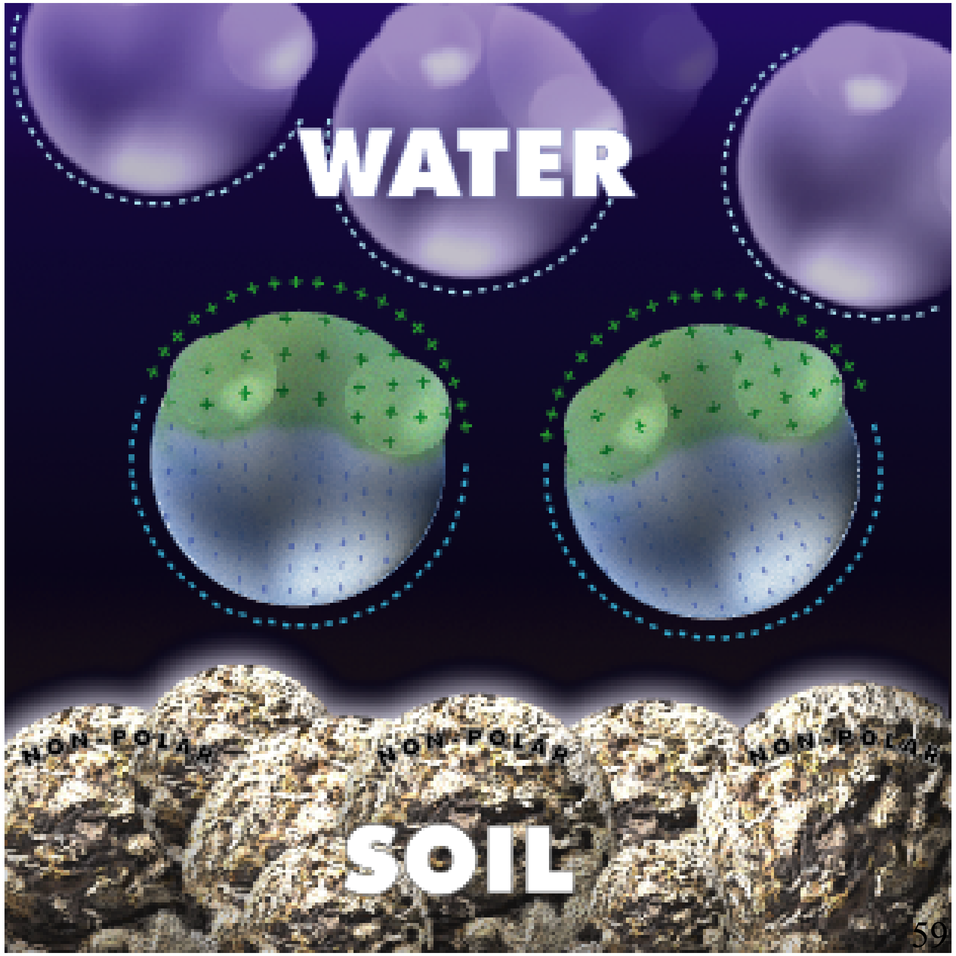


付着の反対現象は？

OPPOSITE OF ADHESION?

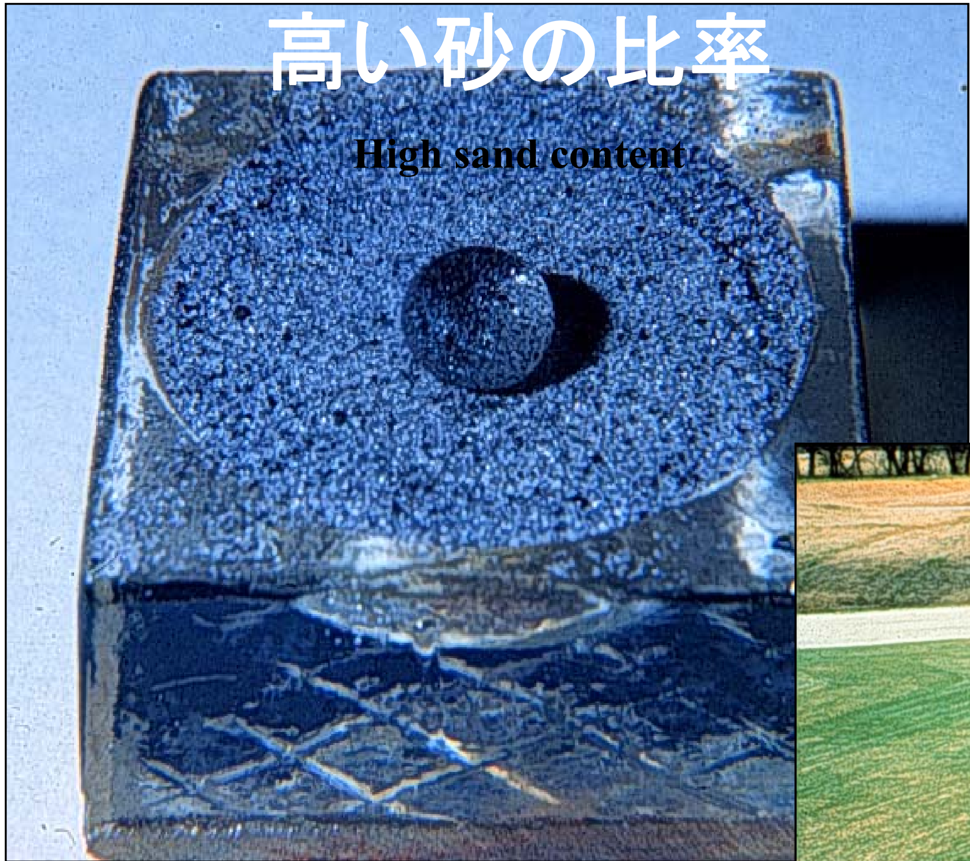


撥水
（疎水性）
WATER REPELLENCY
(hydrophobicity)



土壌撥水の特徴

SWR Characterization



土壌撥水の特徴

SWR Characterization

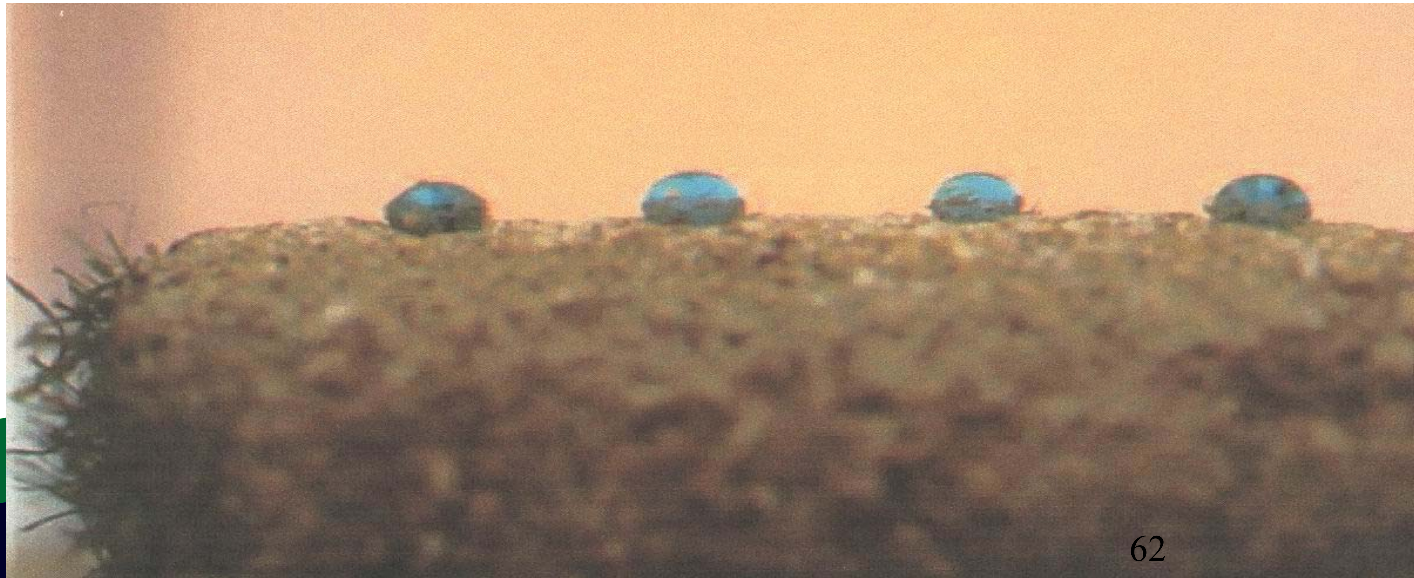
高い有機物質/サッチ

High organic matter / thatch

単一土壌コア法

Intact Soil Core Method

- １５～２0cmの土壌コアを問題の土壌から採取するRemove a 6-to-8 inch intact soil core from the suspect area
- ３～４つのサンプルを取るTake 3-to-4 samples
- 自然乾燥させる（オーブンなどで乾燥させない）Air Dry the samples (DO NOT Dry in an Oven)
- １５mm間隔に水滴を落とすApply Droplets of water every ½ inch
- 土壌に水滴が完全に浸透する時間を計るObserve the time it takes the drop to completely penetrate the soil



水滴浸透力

Water Drop Penetration

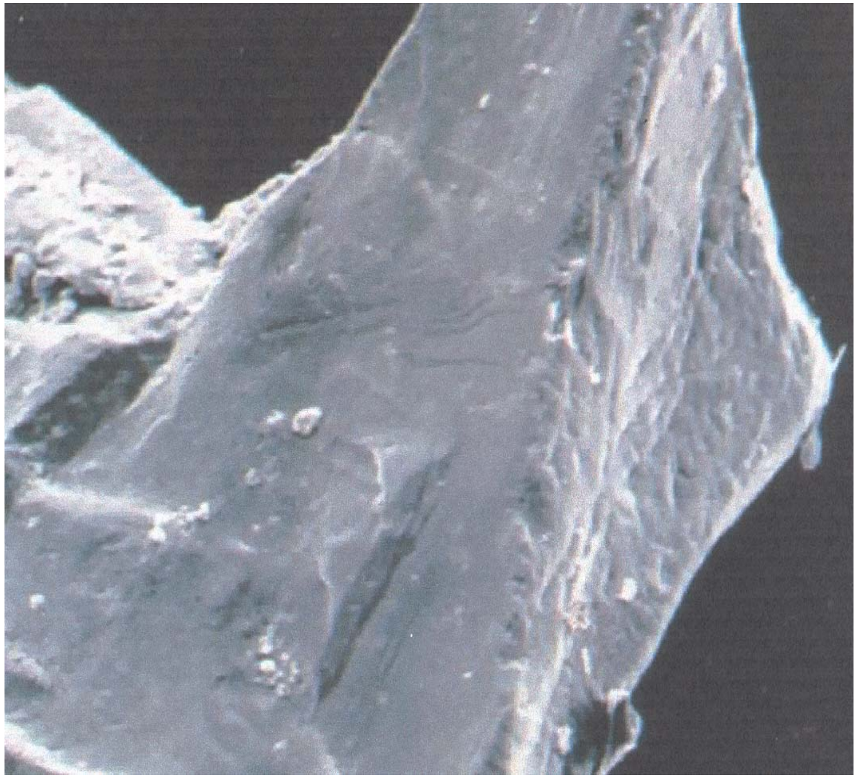
水滴浸透テストの結果分析

Water Drop Penetration Test Classification for Soil Water Repellency

WDPT (秒) seconds	疎水度 Degree of Repellency
0 – 5	なし None
5 – 60	少々 Slight
60 – 600	中から高 Moderate to High
600 – 3,600	激しい Severe
> 3,600	激甚 Extreme

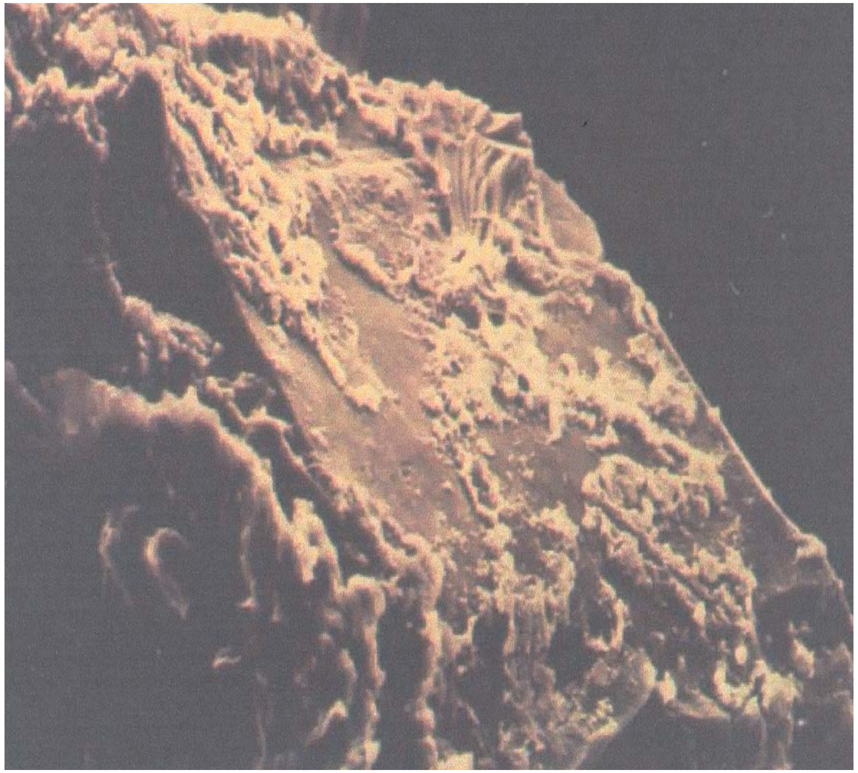
電子顕微鏡写真

Electron Micrographs of Sand Particles



有機コーティングのなり砂粒子

Electron Micrograph of sand particle with no organic coating



有機コーティングされた砂粒子

Electron Micrograph of sand particle with organic coating

浸透剤の事実
SURFACTANT FACTS

非イオン系浸透剤

Non-ionic Surfactant
Polymer Structure

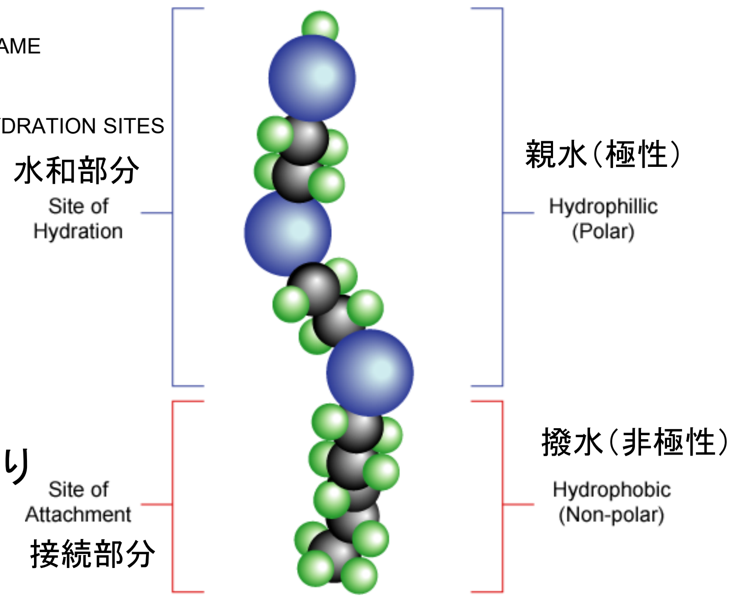
浸透剤は全て同じではありません NOT ALL SURFACTANTS ARE THE SAME

浸透剤は水溶処理パターンを作ります SURFACTANTS PROVIDE HYDRATION SITES

浸透剤は“水和処理パターン”を作ります
SURFACTANTS CAN ESTABLISH A “PATTERN OF HYDRATION”

浸透剤の処理パターンは使用した浸透剤の種類によって決まります
SURFACTANT PATTERN DETERMINED BY TYPE OF SURFACTANT USED

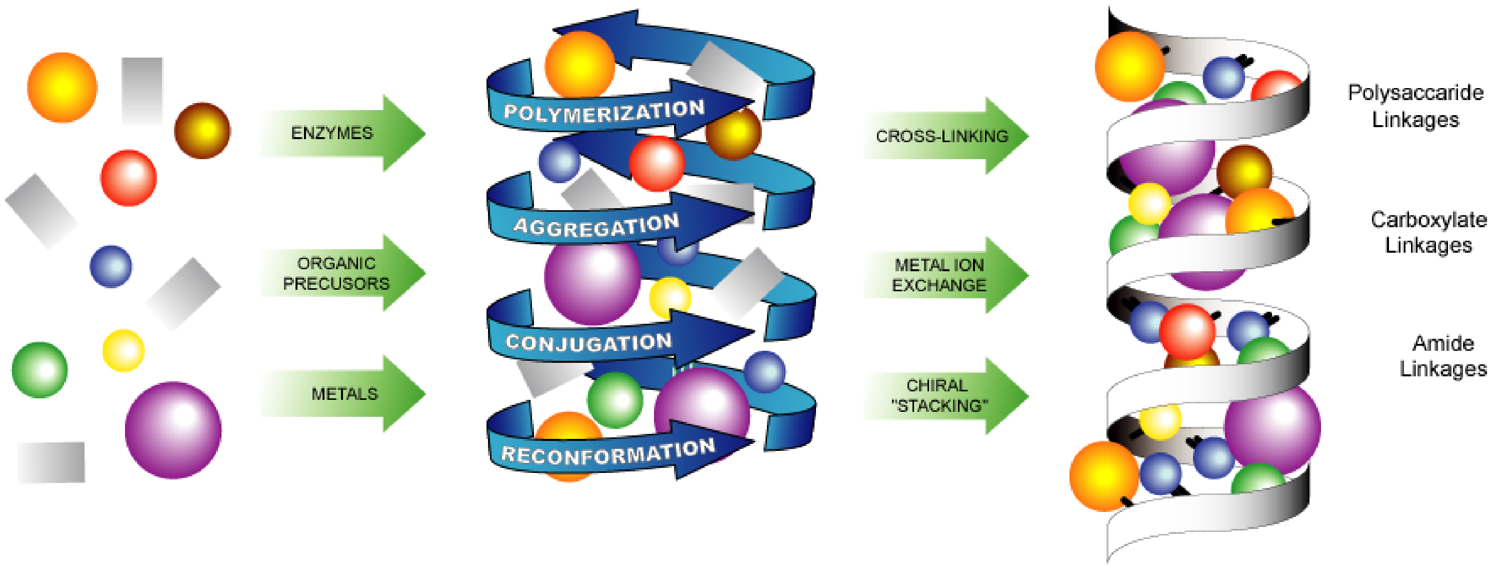
浸透剤は撥水症状の原因物質の生成を予防したり、取り去ることはできません
URFACTANTS DON’T CURE OR PREVENT HYDROPHOBICITY



浸透剤は芝生が使用できる水と水の動きに影響を与える撥水症状を予防し、処理することができる

SURFACTANTS TREAT OR PREVENT CONDITIONS OF HYDROPHOBICITY FROM IMPACTING WATER MOVEMENT AND AVAILABILITY TO TURF PLANT

HUMIC ACID GROWTH



HUMIC ACID MONOMER BUILDING BLOCKS

フミン酸の単量体が固まりを作る

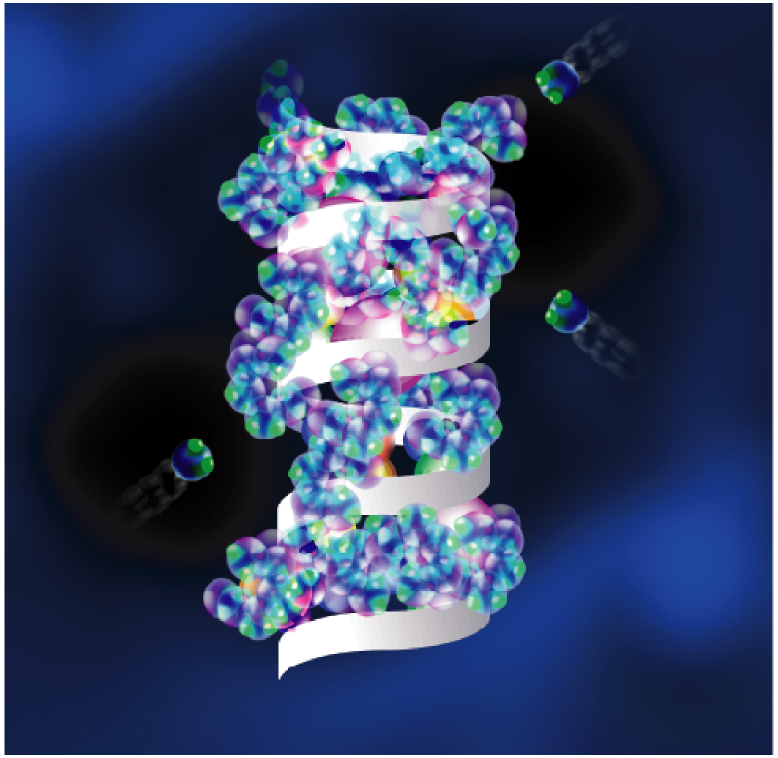
TRANSFORMATION PROCESSES

変化の過程

HUMIC ACID MACROMOLECULE

フミン酸の分子集合体

もしフミン酸がマイナス側であれば水を引きつけることができます
IF HUMIC ACIDS HAVE NEGATIVE SITES AND CAN BE HYDRATED...



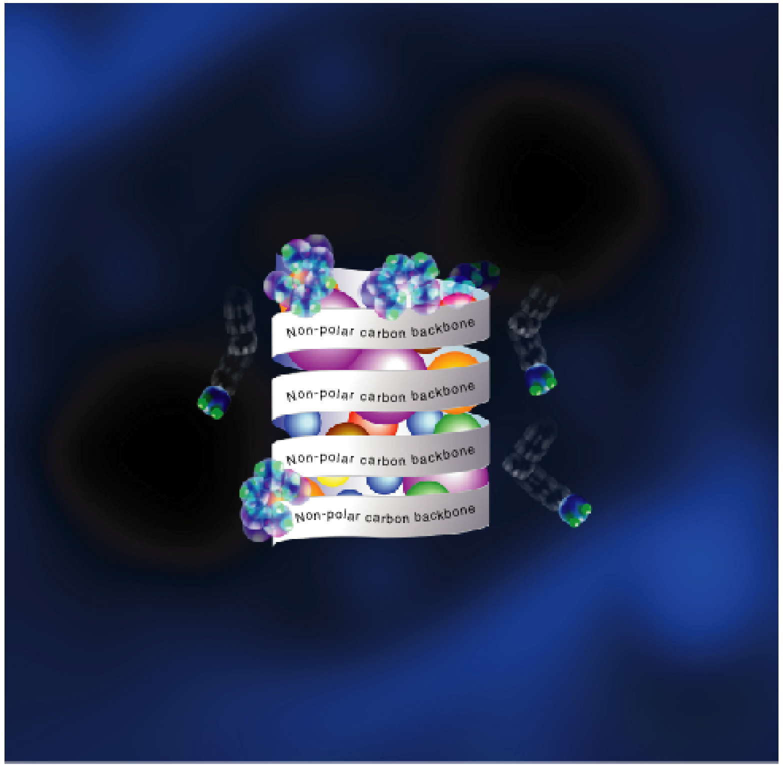
Hydrated Humic Acid　水和フミン酸

ではなぜ撥水症状の原因になるのでしょうか？

WHY ARE THEY ATTRIBUTED TOWATER REPELLENCY?

なぜなら低温/高湿から高温/低湿状況に変わると撥水状態に変わるのです

BECAUSE THEY ARE RENDERED HYDROPHOBIC WHEN CONDITIONS CHANGE FROM COOL/WET TOHOT/DRY



フミン酸の物理的構造が壊れてしまうのです

THE HUMIC ACID LOOSES ITS STRUCTURAL INTEGRITY

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BEST APEX
16777 HOWLAND ROAD, P.O. BOX 198, LATHROP, CA 95330 • (209) 858-2511 • FAX (209) 858-2519

REPORT NUMBER: 06-017-046

GROWER: CENT CREEK

SEND TO: HUGH ENTERPRISE LTD
10-1 NISHIGOKENCHO
SHINJUKU-KU, TOKYO, JAPAN

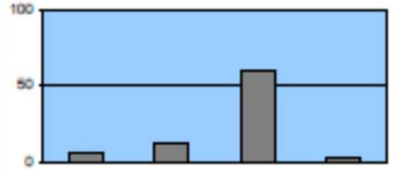
SUBMITTED BY: TANAKA

Graphical Soil Analysis Report

DATE OF REPORT: 01/19/06 **LAB NO:** 57898 **SAMPLE ID:** F4W **PAGE:** 1

Analyte	Organic Matter percent	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	
Results	2.7	4	86	62	75	51	416	25	6	4.0	1	116	0.9	0.1	

Percent
Cation Saturation (computed)



Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %
5.6	12.1	60.2	3.1

LOW AVERAGE HIGH

ECe dS/m	0.2	INCREASING SALINITY →

CEC meq/100g	Ex. Lime	pH
3.4	L	5.8

ACIDIC BASIC
← INCREASING NEED FOR LIME

Buffer pH: 7.0

NaHCO3-P unreliable at this soil pH

Soil Fertility Guidelines

CROP: ZOYSIAGRASS **RATE:** lb/1000 sq ft **NOTES:**

Dolomite (70 score)	Lime (70 score)	Gypsum	Elemental Sulfur	Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B	
0				4.5	1	4	0.5	0.6		*			*	

COMMENTS

LIGHT TEXTURED SOILS that exhibit low pH may require very little lime (0) to raise pH due to their low buffering capacity. Less than 1000 lb/ac (25 lb/1000 sq ft) may be sufficient.
NITROGEN: The above requirements may need to be adjusted according to local conditions. Follow label instructions as controlled-release fertilizers may be applied less frequently.
POTASH: Optimum wear tolerance may be achieved by applying up to 8 lb potash/1000 sq ft per year. The above guidelines may need to be modified if tissue analyses indicate so.
MAGNESIUM: If less than 50-70 ppm but pH is normal/high, consider Epsom salt, sulfate of potash magnesia, magnesium nitrate, chelates, lignosulfonates or other neutral magnesium salts.

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

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16777 HOWLAND ROAD, P.O. BOX 198, LATHROP, CA 95330 • (209) 858-2511 • FAX (209) 858-2519

REPORT NUMBER: 06-321-006

CLIENT NO: 1586 **SUBMITTED BY:** HUGH ENTERPRISE LTD

SEND TO: HUGH ENTERPRISE LTD
10-1 NISHIGOKENCHO
SHINJUKU-KU TOKYO JAPAN

GROWER: KITAKAMI

Graphical Plant Analysis Report

DATE OF REPORT: 11/21/2006 **LAB NO:** 47418 **SAMPLE ID:** G1 **CROP:** CREEPING BENT **PAGE:** 1

Analyte	Nitrogen N %	Sulfur S %	Phosphorus P %	Potassium K %	Magnesium Mg %	Calcium Ca %	Sodium Na %	Chloride Cl %	Iron Fe ppm	Aluminum Al ppm	Manganese Mn ppm	Boron B ppm	Copper Cu ppm	Zinc Zn ppm	Nitrate-N NO_3-N ppm	Phosphate PO_4-P ppm	
Test Results	2.99	0.34	0.38	1.66	0.24	0.82	0.02		3008	2237	190	16	30	48			
Normal Range	4.50 6.00	0.20 0.45	0.30 0.60	2.20 2.60	0.25 0.30	0.50 0.75	0.01 0.19		100 300	20 300	50 100	9 20	9 30	25 75			

Ratios	N/S	N/P	N/K	Ca/Mg	N/Ca	K/Mg	P/S	Fe/Mn	Fe/Al	K/Mn	Ca/B	Cu/Mo	P/Zn				
Actual	8.8	7.8	1.8	3.4	3.6	6.9	1.1	16.0	1.3	88	525		80				
Expected	17.0	11.0	2.1	2.4	8.3	9.6	1.5	2.7	2.0	320	400		90				

DATE SAMPLED: / **GROWTH STAGE / PLANT PART:** /

COMMENTS

POTASSIUM: A deficiency may arise in shallow, compacted, poorly aerated soils or leached sands. High levels of Na, Ca, or Mg may suppress K uptake.
IRON: If both Fe and Al are excessive, it may be simply due to soil/dust contamination. A true toxicity shows as a bronzing on leaves with tiny brown spots.

DEFINITION OF INTERPRETATION RATINGS

- Deficient: Plants should be showing visible symptons of a nutritional deficiency. Plant growth would definitely be curtailed by an insufficient amount of this element.
- Low: Plants may be normal in appearance but probably will be responsive to fertilization with this element.
- Sufficient: Plants contain adequate amounts of this element for maximum yield and are normal in appearance.
- High: Optimum yields can be expected and plants are normal in appearance. However, concentrations of this element are higher than normally expected.
- Excessive: Plants probably show symptoms of a nutritional disorder or stunted growth. Yields may be reduced significantly by an excessive amount of this element.

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

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Thank You