# Basics of Hydroponics

# Me = Alice

Prosistance activist

Gerilla gardener

Social sustainability consult

Sustainable urban development - for EVERYONE

Short hydro-history
How do plants grow, and how to measure stuff that matters
Common systems

All slides and additional info available on:
https://events.ccc.de/camp/2015/Fahrplan/events/6959.html

Questions are welcome at our camp found by The Spiegeleimuseum sign, T-10 on the map.

**@hjartats**
**@planteringsnormen**
**@boodlaren**
**alice@bulukin.se**

Hydro = Water

Ponos = Work

(greek) Working water

Soilless growing

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

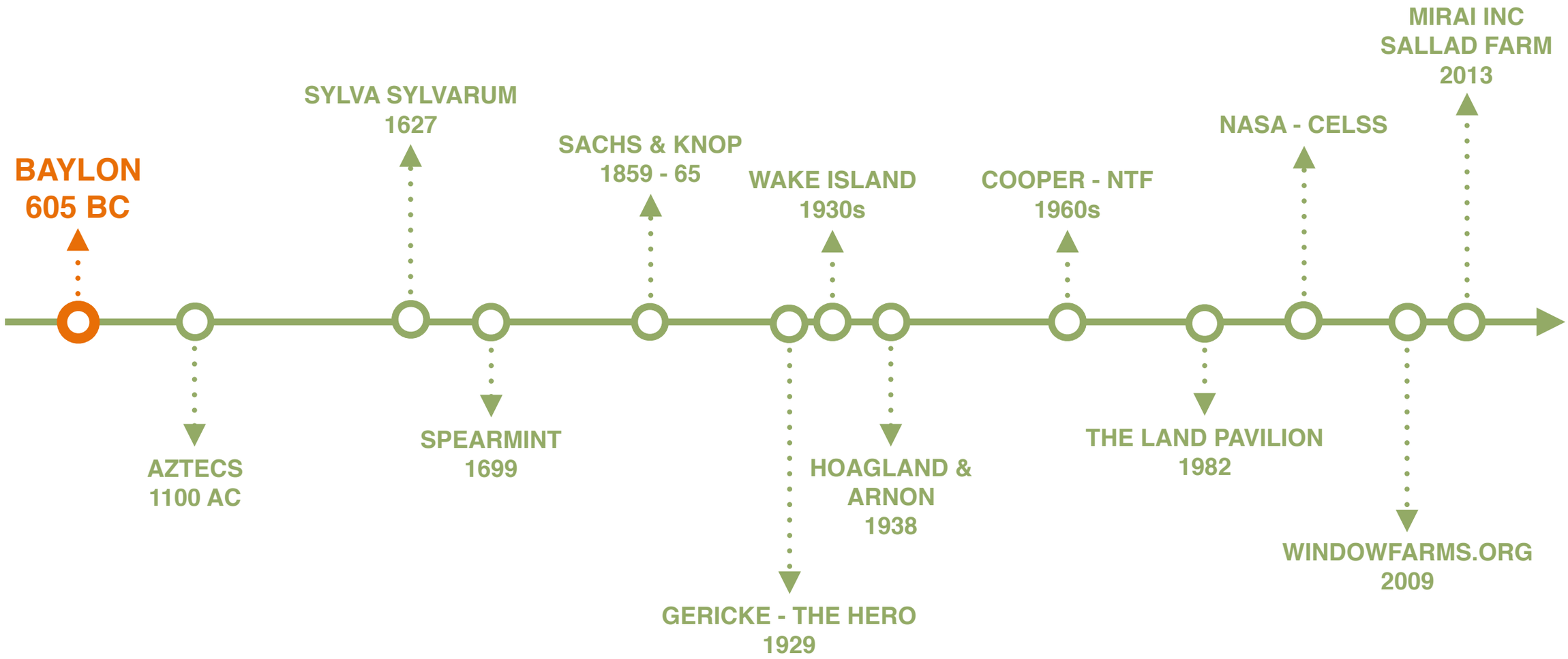
COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013


BAYLON
605 BC
AZTECS
1100 AC
SYLVA SYLVARUM
1627
SPEARMINT
1699
SACHS & KNOP
1859 - 65
GERICKE - THE HERO
1929
WAKE ISLAND
1930s
HOAGLAND &
ARNON
1938
COOPER - NTF
1960s
THE LAND PAVILION
1982
NASA - CELSS
WINDOWFARMS.ORG
2009
MIRAI INC
SALLAD FARM
2013

Wikimedia

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

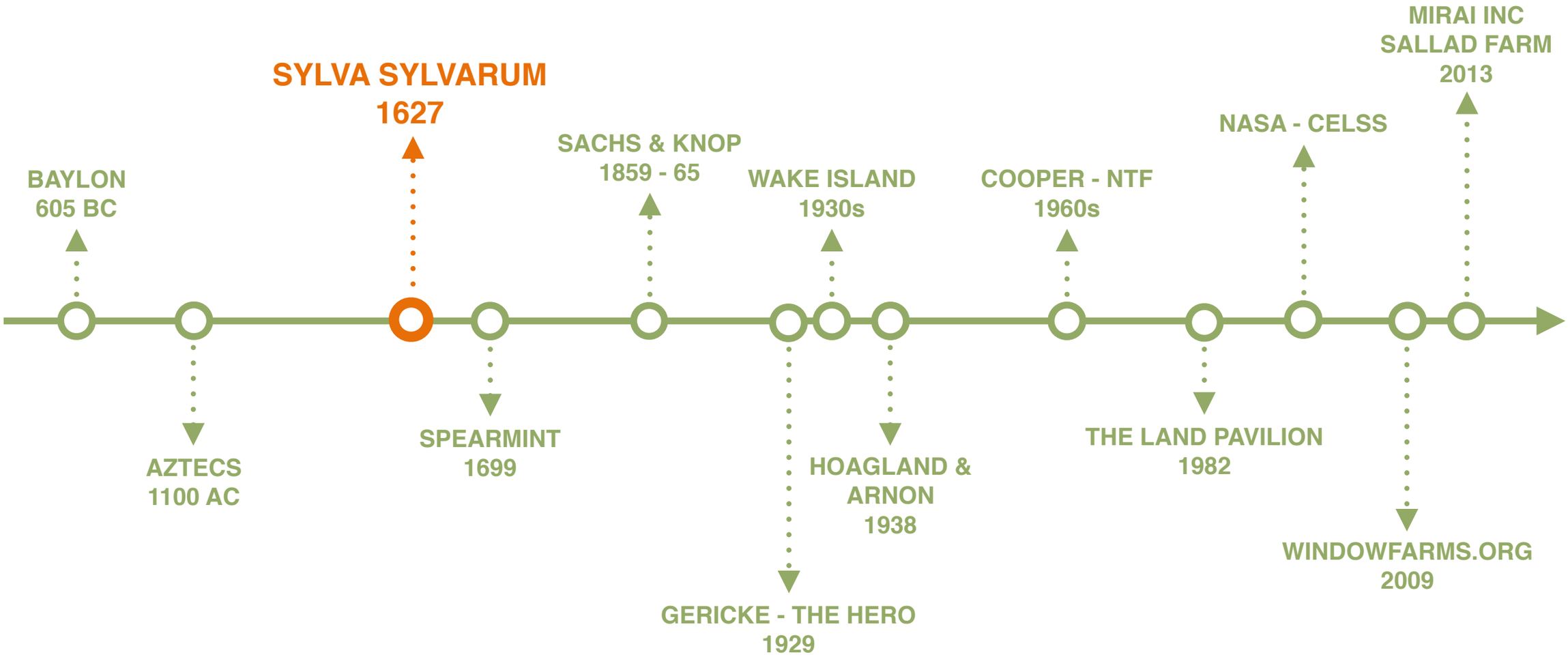
THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013

http://ezgrogarden.com/


BAYLON
605 BC
AZTECS
1100 AC
SYLVA SYLVARUM
1627
SPEARMINT
1699
SACHS & KNOP
1859 - 65
GERICKE - THE HERO
1929
WAKE ISLAND
1930s
HOAGLAND &
ARNON
1938
COOPER - NTF
1960s
THE LAND PAVILION
1982
NASA - CELSS
WINDOWFARMS.ORG
2009
MIRAI INC
SALLAD FARM
2013


NITI MELIORA
MO RA
Hon.mi Francisci Bacon. Baro de Verul:
lam Vice-Comes Sti Albani Mortuus 9 Aprilis,
Anno Dni. 1626 Amog. Aetat 66.


יהי
Et vidit Deus lucem quod esset bona.
Mundus Intellectualis
SYLVA SYLVARVM
OR
A NATVRALL HISTORY
In ten Centuries.
Written by the right Hon.ble Francis
Lo Verulam Visscount St Alban.
Published after y Autho Deatly
by W: RAWLEY D of Divi
nity. &c
Tho Cecill sculp.
LONDON
Printed for W. Lee and are to be sould at
the Great Turks head next to the Mytre
Taverne in Fleetstreet
Anno
1631

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013

**Table 2.1 Knop's Nutrient Solution**

| *Reagent* | *g/L* |
|---|---|
| Potassium nitrate ($KNO_3$) | 0.2 |
| Calcium nitrate [$Ca(NO_3)_2 \cdot 4H_2O$] | 0.8 |
| Monopotassium phosphate ($KH_2PO_4$) | 0.2 |
| Magnesium sulfate ($MgSO_4 \cdot 7H_2O$) | 0.2 |
| Ferric phosphate ($FePO_4$) | 0.1 |

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

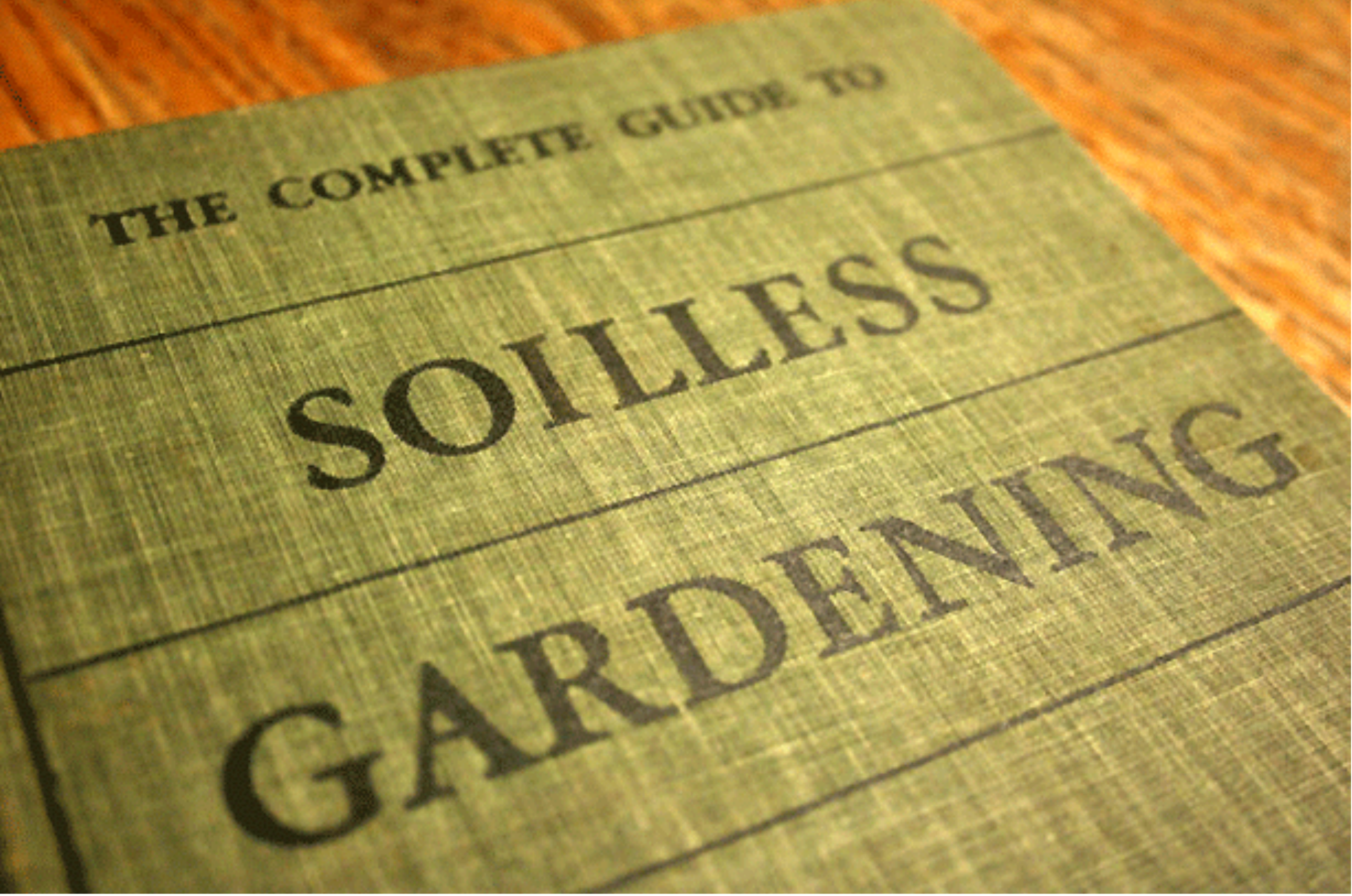
COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013




www.urbangardensweb.com

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013


Wikimedia

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013

| Stock Soln. | Ingredients | Amount (gm/Litre) | Ml./Litre of Final Solution |
|---|---|---|---|
| A | $Ca(NO_3)_2 \cdot 4H_2O$ | 236.15 | 5 |
| B | $KNO_3$ | 101.11 | 5 |
| C | $MgSO_4$ | 120.40 | 2 |
| D | $KH_2PO_4$ | 136.10 | 1 |
| E | $CaCl_2 \cdot 2H_2O$ | 183.73 | 1 |
| F | Sequestrene (Geigy) | 25.00 | 4 |
| Micro Modified | $H_3BO_3$ | 0.572 | 1 |
| | $MnCl_2 \cdot 4H_2O$ | 0.362 | |
| | $ZnCl_2$ | 0.110 | |
| | $CuCl_2 \cdot 2H_2O$ | 0.050 | |
| | $Na_2MoO_4 \cdot 2H_2O$ | 0.025 | |

Adjust $p^H$ 6.0 - 6.5

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

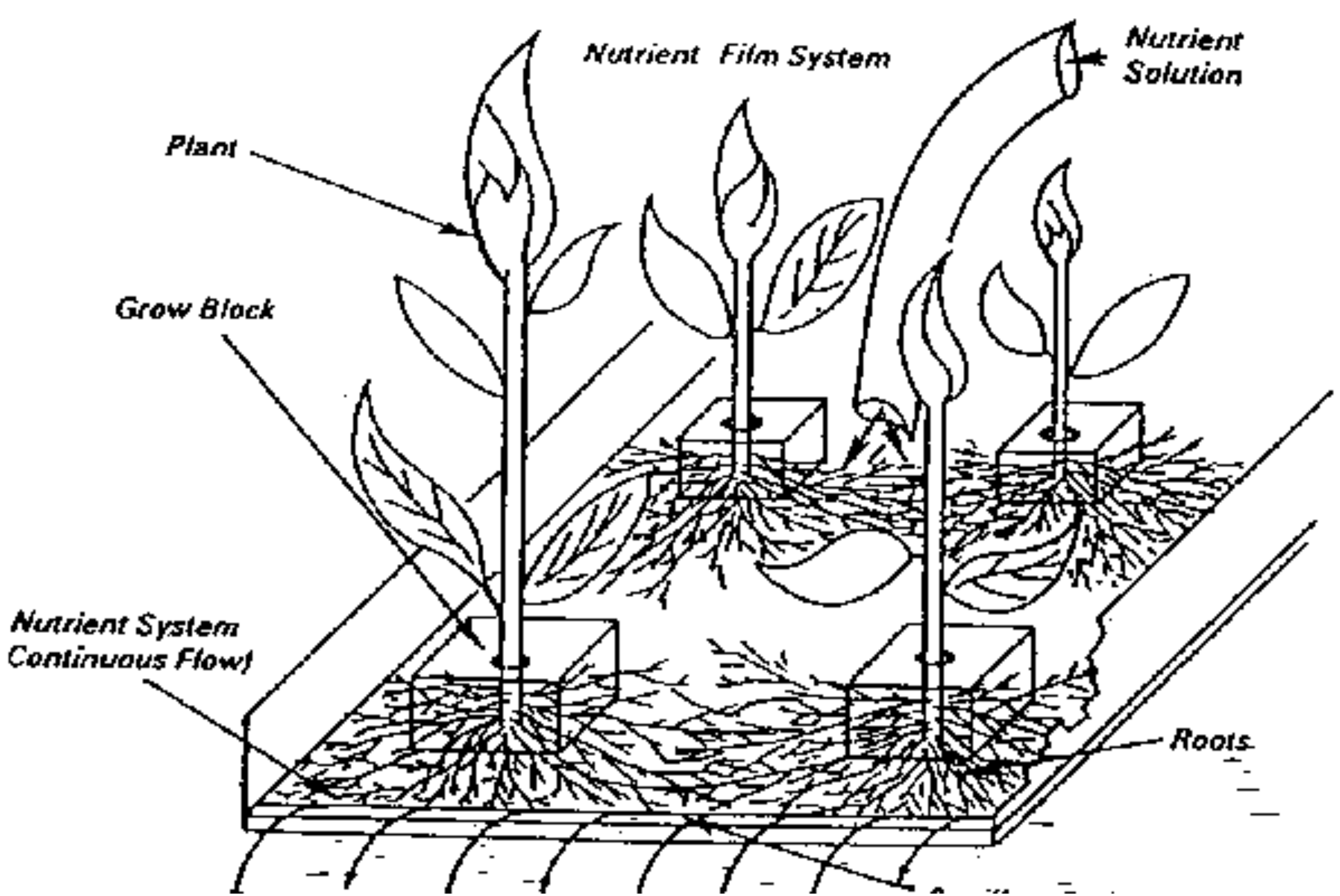
**COOPER - NTF**
**1960s**

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013


Nutrient Film System
Nutrient Solution
Plant
Grow Block
Nutrient System
Continuous Flow!
Roots

www.fao.org

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013

Photo - Britt Conley

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

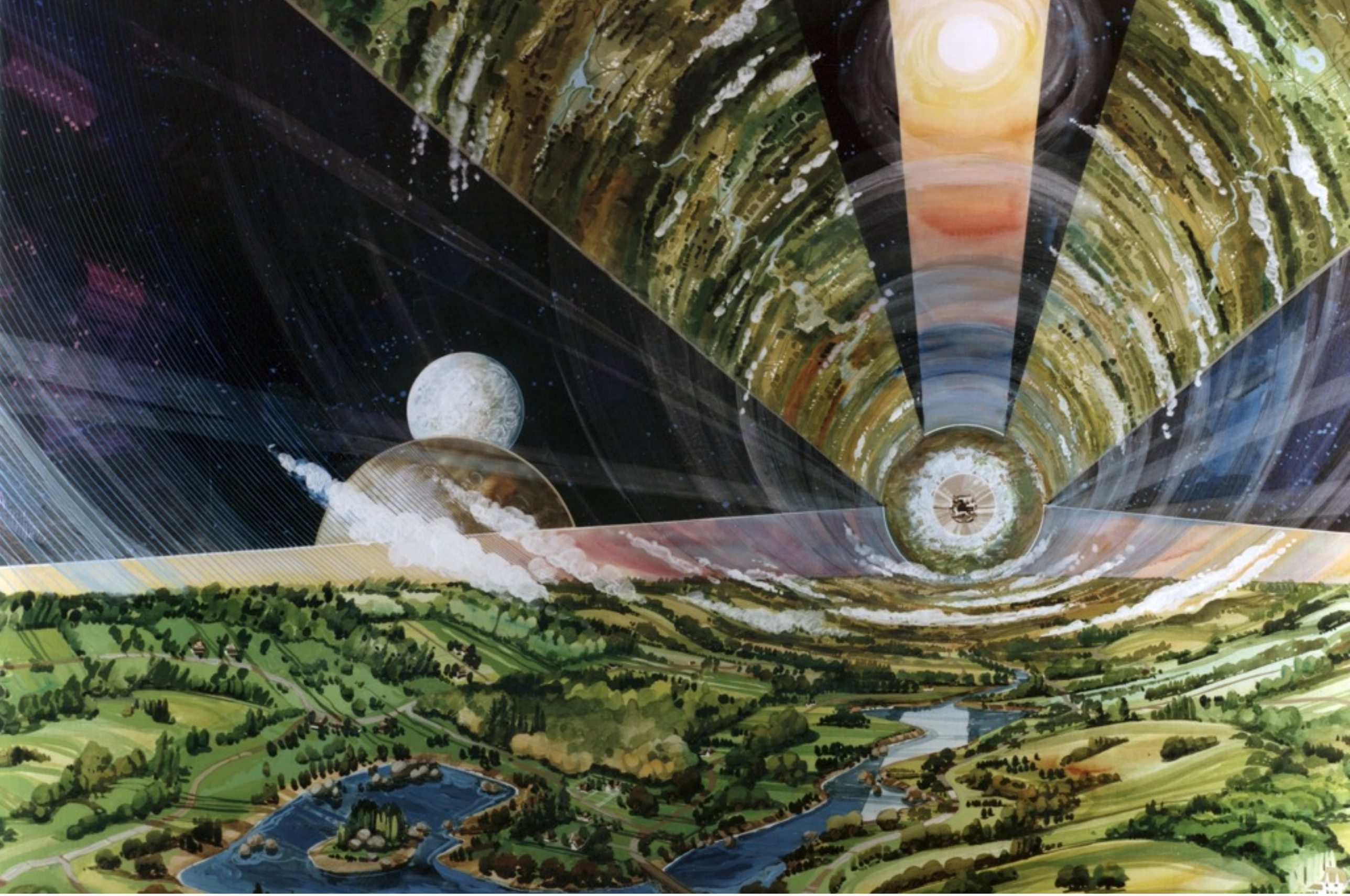
COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

WINDOWFARMS.ORG
2009

MIRAI INC
SALLAD FARM
2013



Rick Guidice, NASA

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

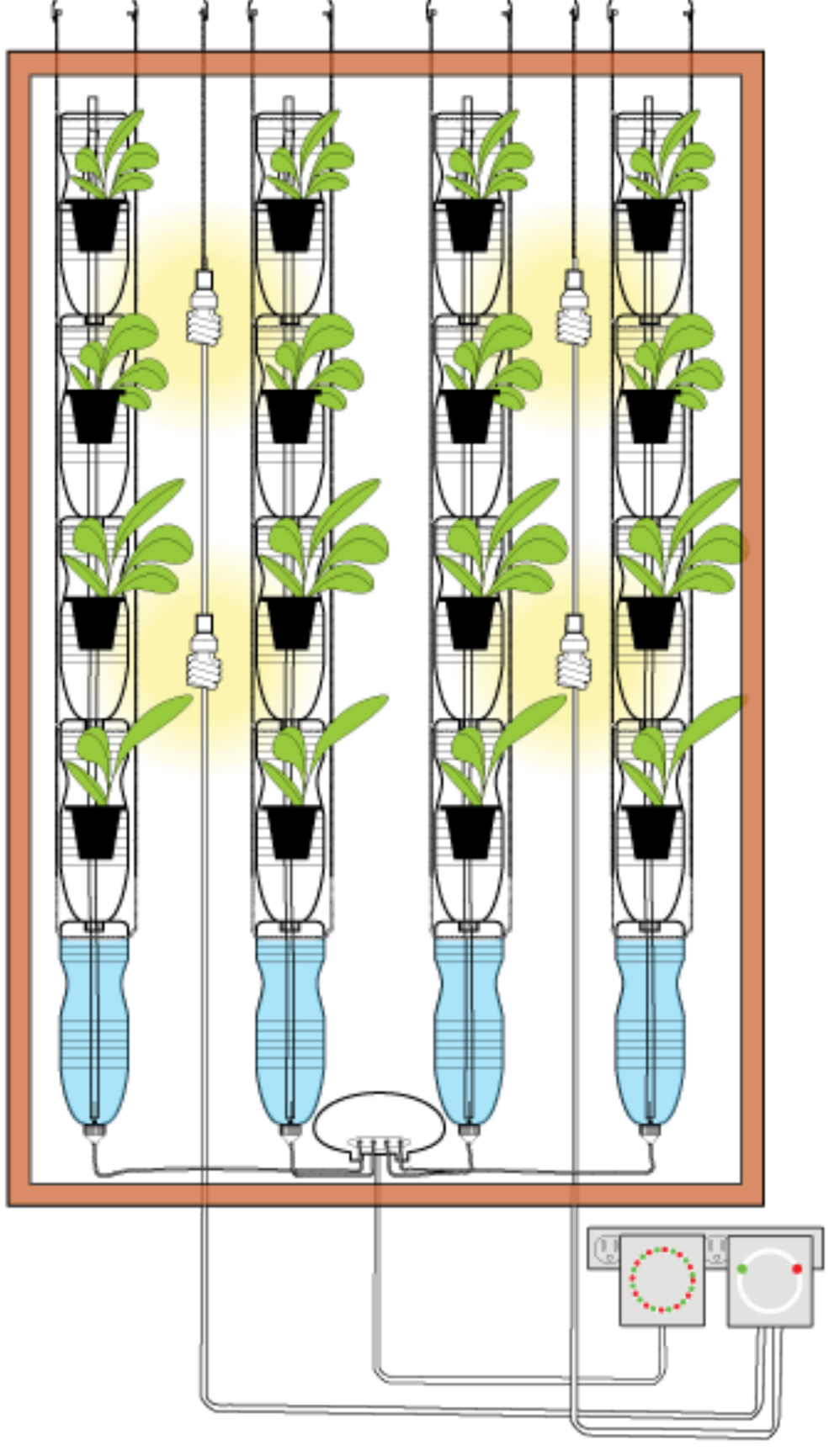
COOPER - NTF
1960s

THE LAND PAVILION
1982

NASA - CELSS

MIRAI INC
SALLAD FARM
2013

WINDOWFARMS.ORG
2009



windowfarms.org

BAYLON
605 BC

AZTECS
1100 AC

SYLVA SYLVARUM
1627

SPEARMINT
1699

SACHS & KNOP
1859 - 65

GERICKE - THE HERO
1929

WAKE ISLAND
1930s

HOAGLAND &
ARNON
1938

COOPER - NTF
1960s

THE LAND PAVILION
1982

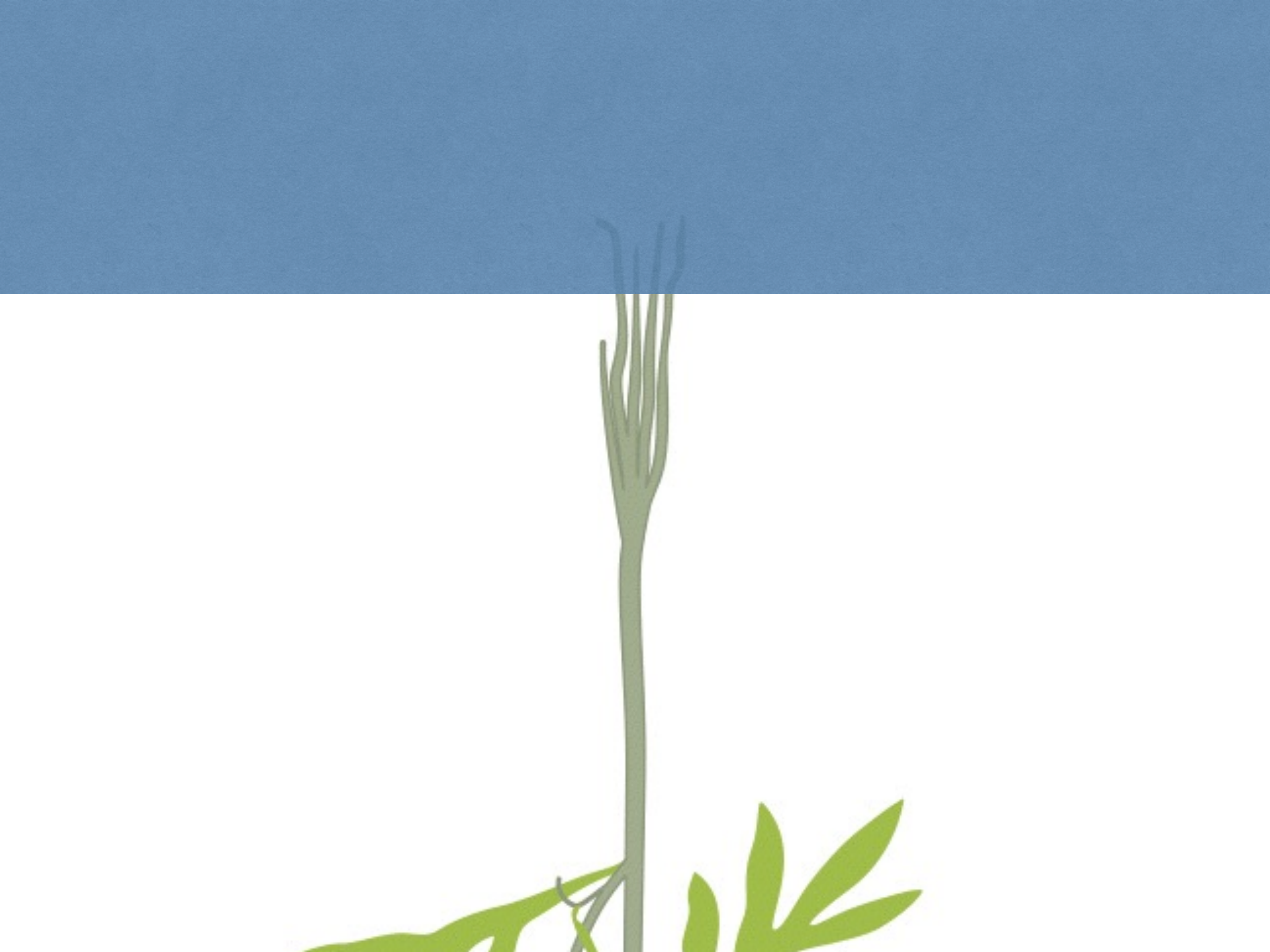
NASA - CELSS

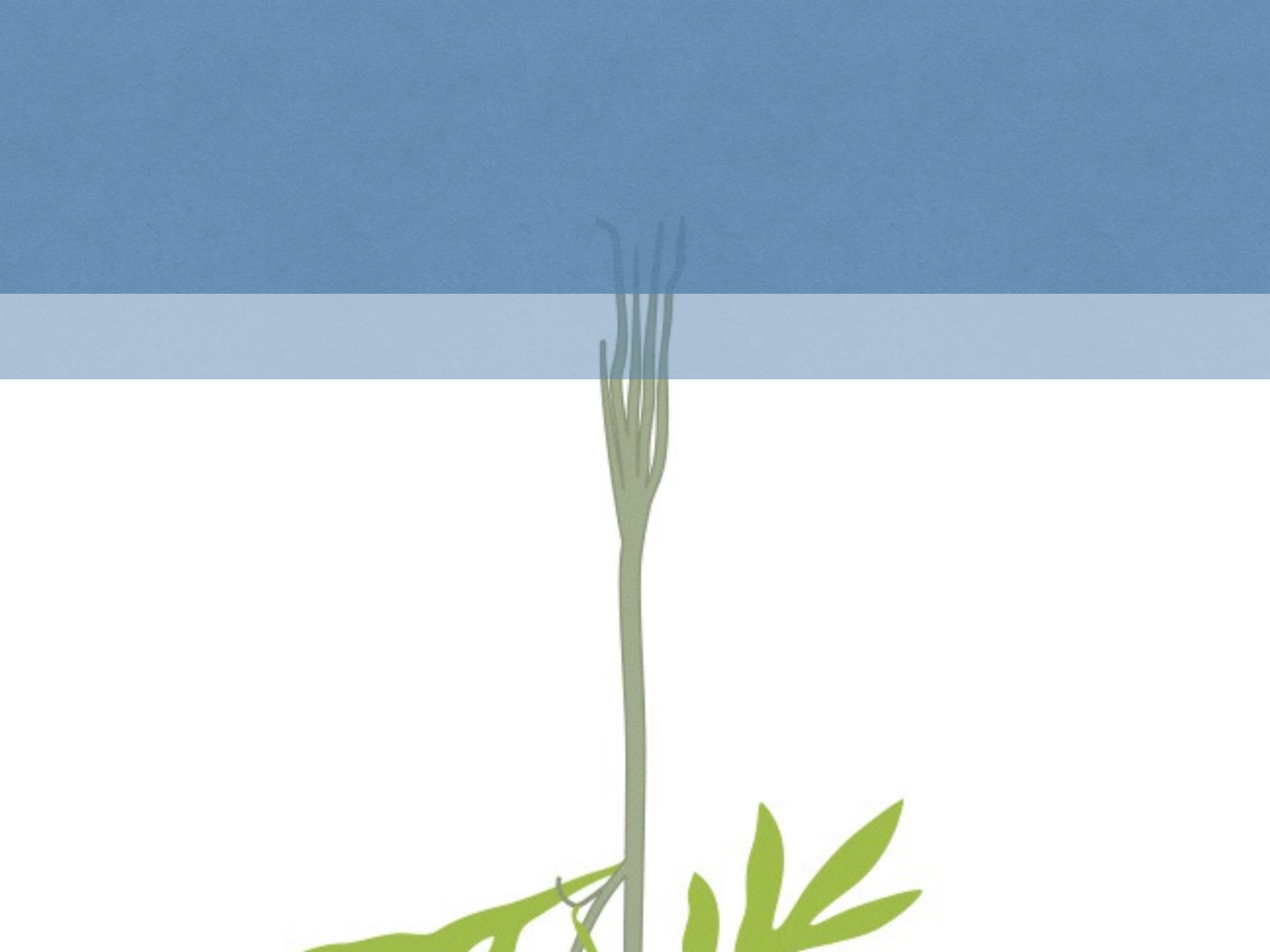
WINDOWFARMS.ORG
2009

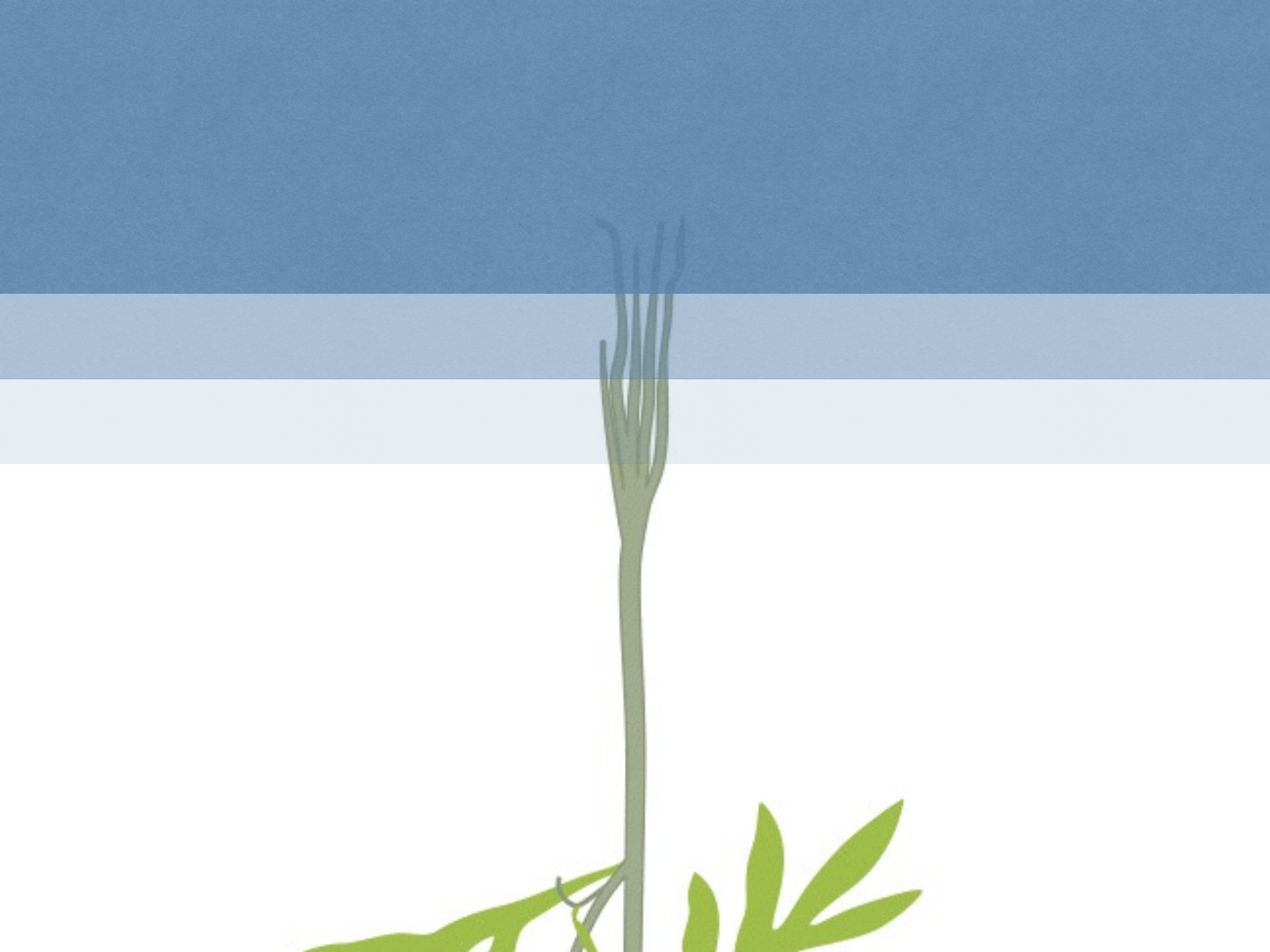
MIRAI INC
SALLAD FARM
2013

http://www.zmescience.com/

# How plants grow in hydroponics







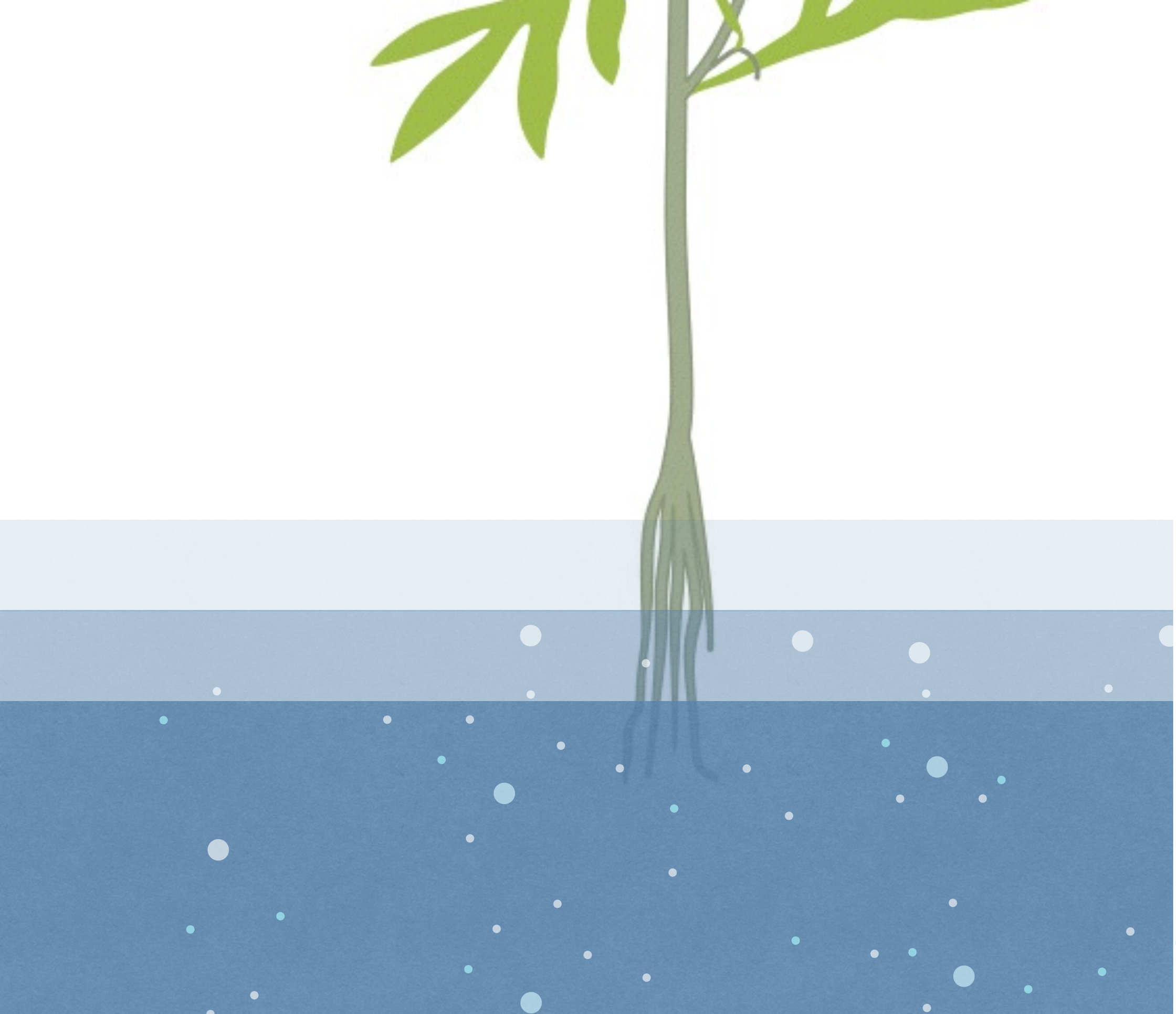
The water


Water level

Water level

pH


Water level
pH 5,8-6,5


Water level
pH 5,8-6,5
EC

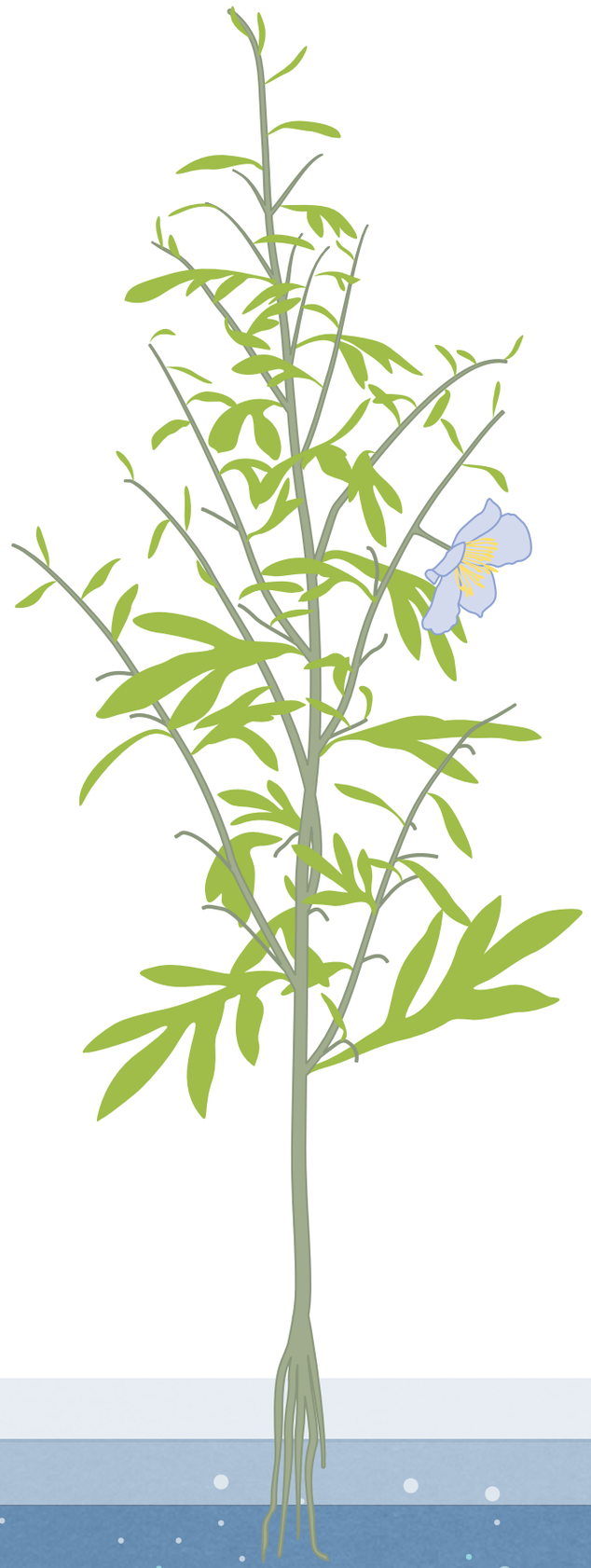
# Measurements

Water

Water level

pH 5,8-6,5

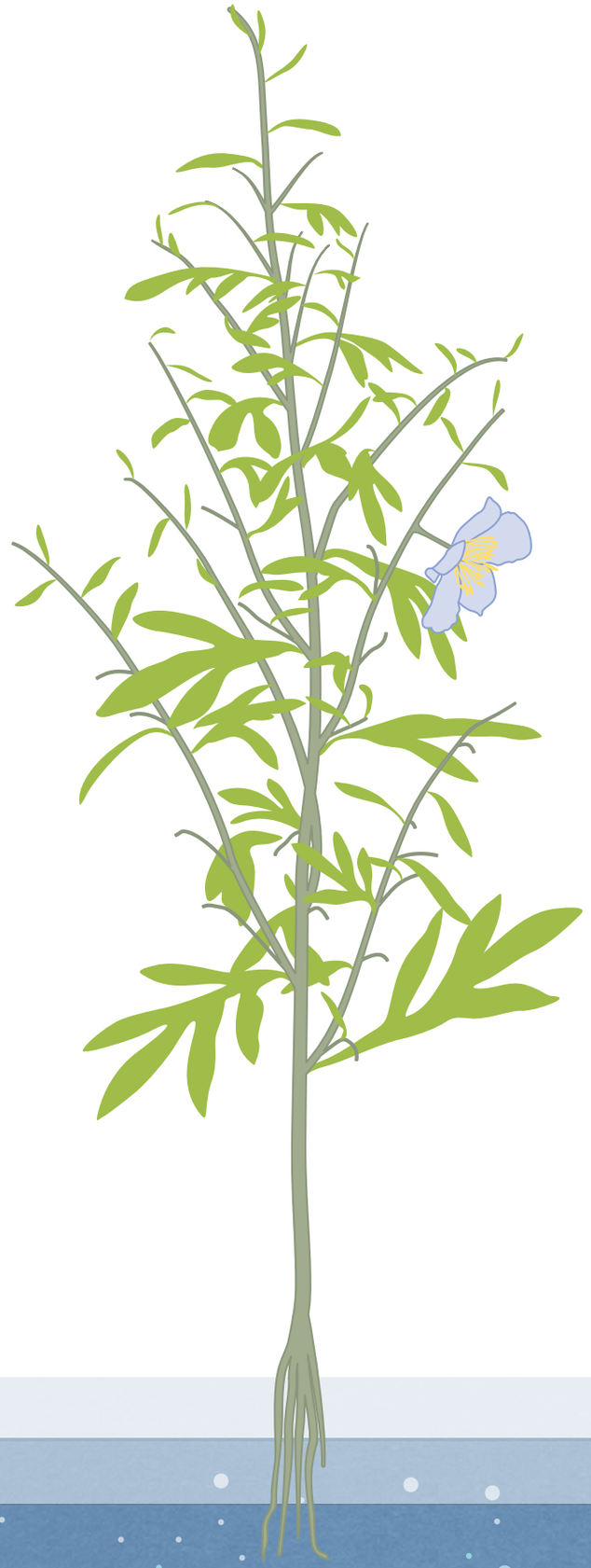
EC



# The nutrients

Macro

- (N) Nitrogen
- (P) Phosphorus
- (K) Potassium



## Measurements

Water

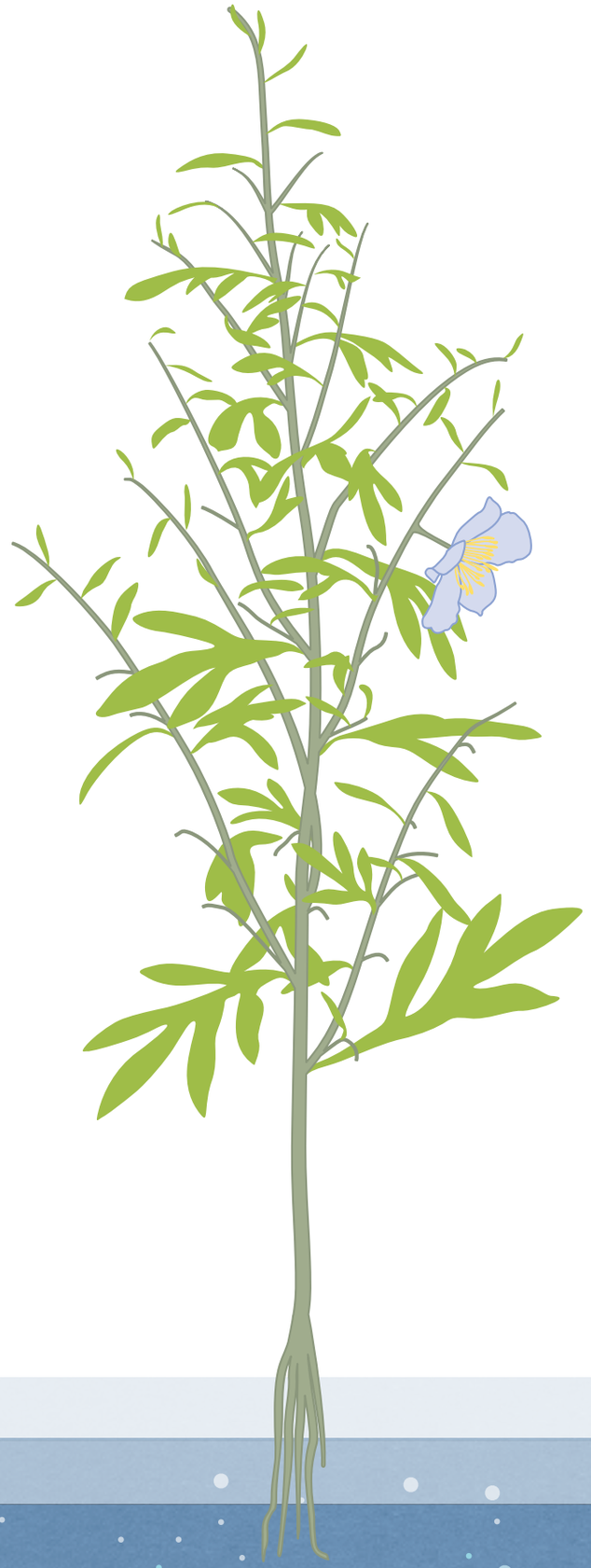
Water level

pH 5,8-6,5

EC

Macro
- (N) Nitrogen
- (P) Phosphorus
- (K) Potassium

2nd Macro
- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium



## Measurements

Water

Water level

pH 5,8-6,5

EC

## Macro

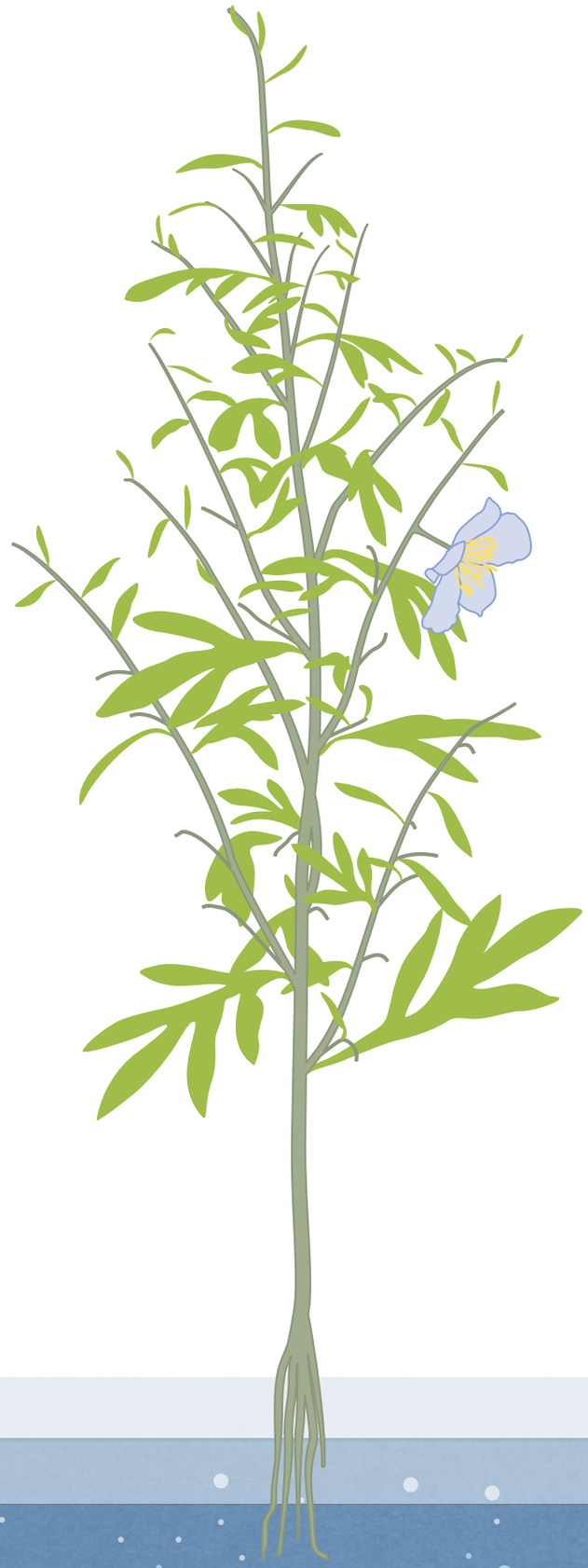
- (N) Nitrogen
- (P) Phosphorus
- (K) Potassium

## 2nd Macro

- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium

## Micro

- (B) Boron
- (Cl) Chlorine
- (Mn) Manganese
- (Fe) Iron
- (Zn) Zinc
- (Cu) Copper
- (Mo) Molybdenum
- (Ni) Nickel



## Measurements

Water

Water level

pH 5,8-6,5

EC

## Macro

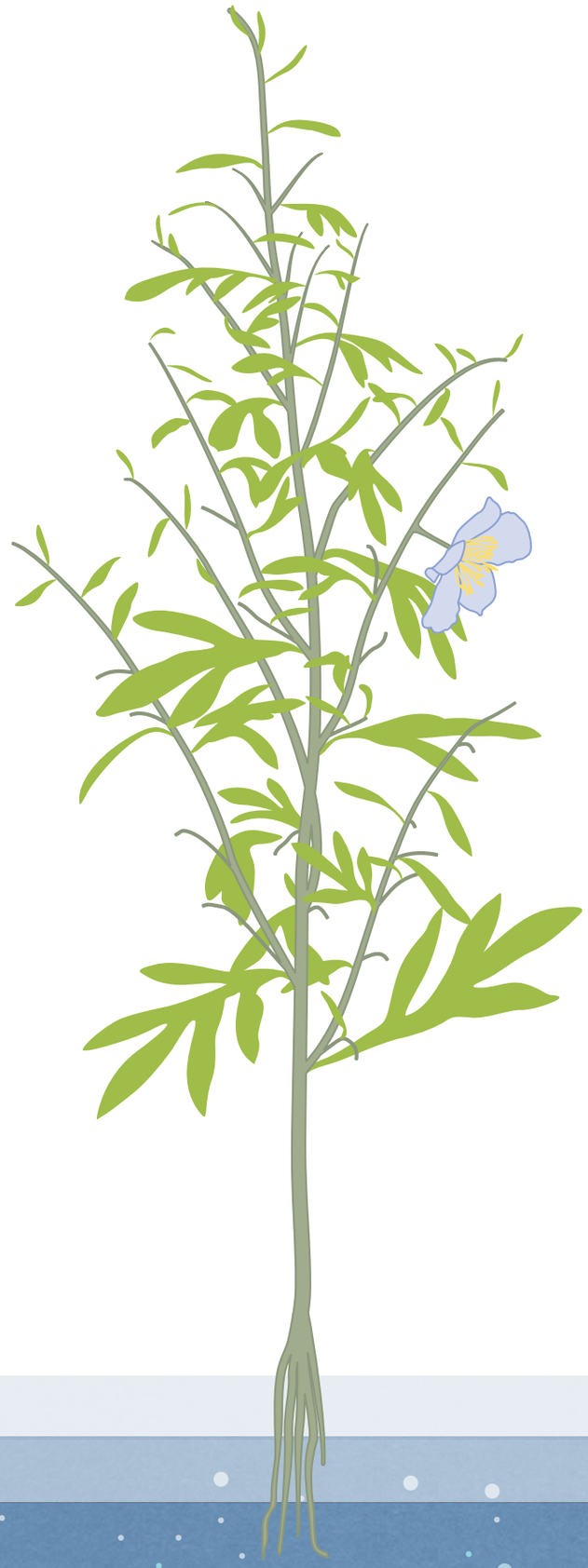
- (N) Nitrogen
  - Biomass
- (P) Phosphorus
- (K) Potassium

## 2nd Macro

- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium

## Micro

- (B) Boron
- (Cl) Chlorine
- (Mn) Manganese
- (Fe) Iron
- (Zn) Zinc
- (Cu) Copper
- (Mo) Molybdenum
- (Ni) Nickel



## Measurements

Water

Water level

pH 5,8-6,5

EC

## Macro

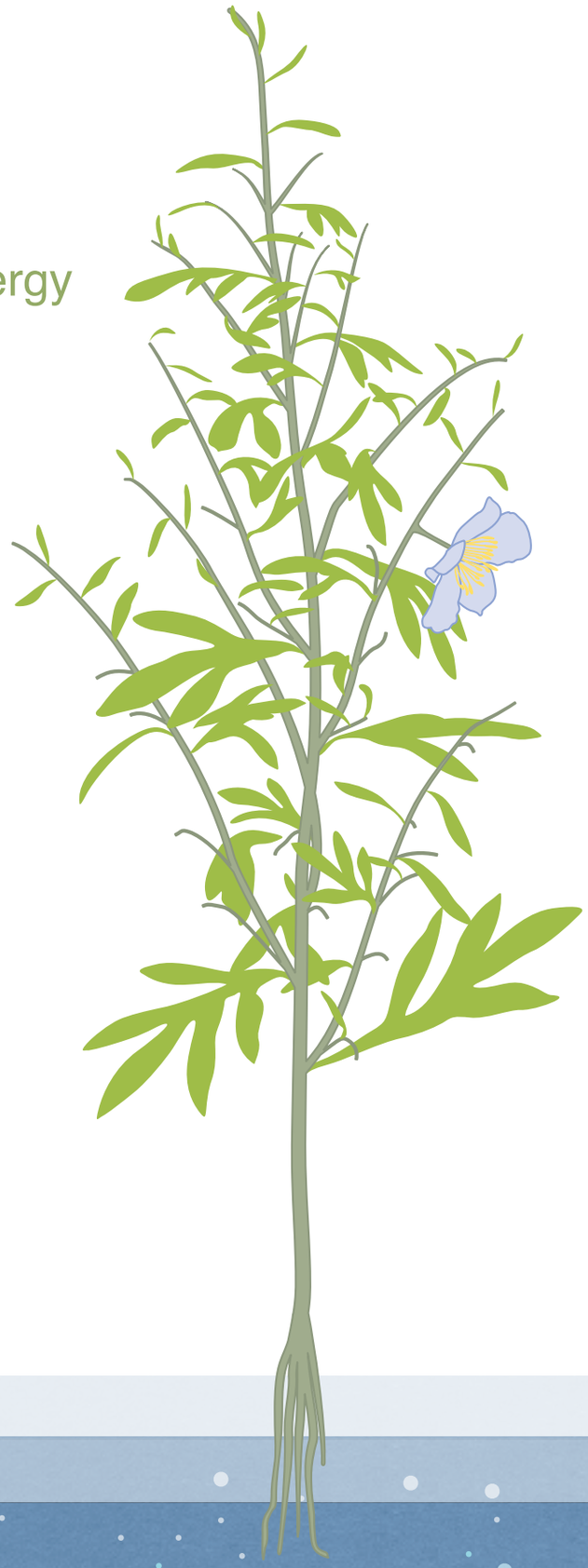
- (N) Nitrogen
  - Biomass
- (P) Phosphorus
  - Flower, fruit & energy
- (K) Potassium

## 2nd Macro

- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium

## Micro

- (B) Boron
- (Cl) Chlorine
- (Mn) Manganese
- (Fe) Iron
- (Zn) Zinc
- (Cu) Copper
- (Mo) Molybdenum
- (Ni) Nickel



## Measurements

Water

Water level

pH 5,8-6,5

EC

## Macro

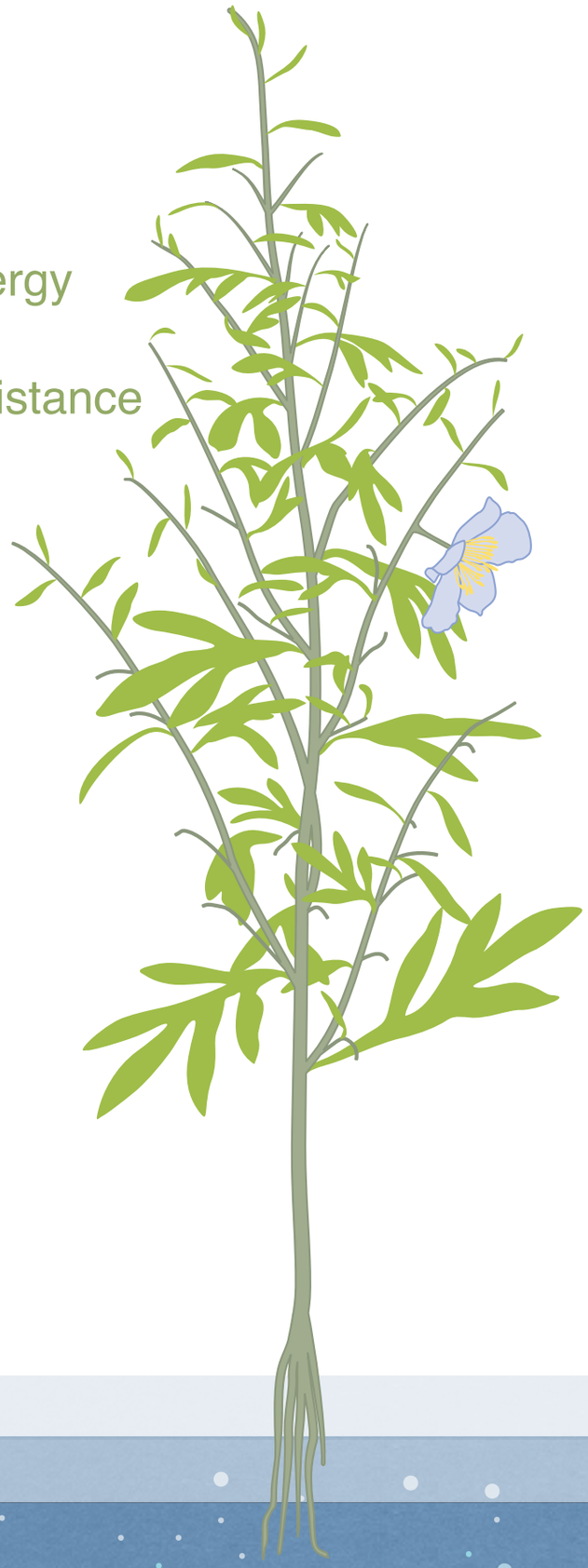
- (N) Nitrogen
  - Biomass
- (P) Phosphorus
  - Flower, fruit & energy
- (K) Potassium
  - Flower, fruit & resistance

## 2nd Macro

- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium

## Micro

- (B) Boron
- (Cl) Chlorine
- (Mn) Manganese
- (Fe) Iron
- (Zn) Zinc
- (Cu) Copper
- (Mo) Molybdenum
- (Ni) Nickel



## Measurements

Water

Water level

pH 5,8-6,5

EC

## Macro

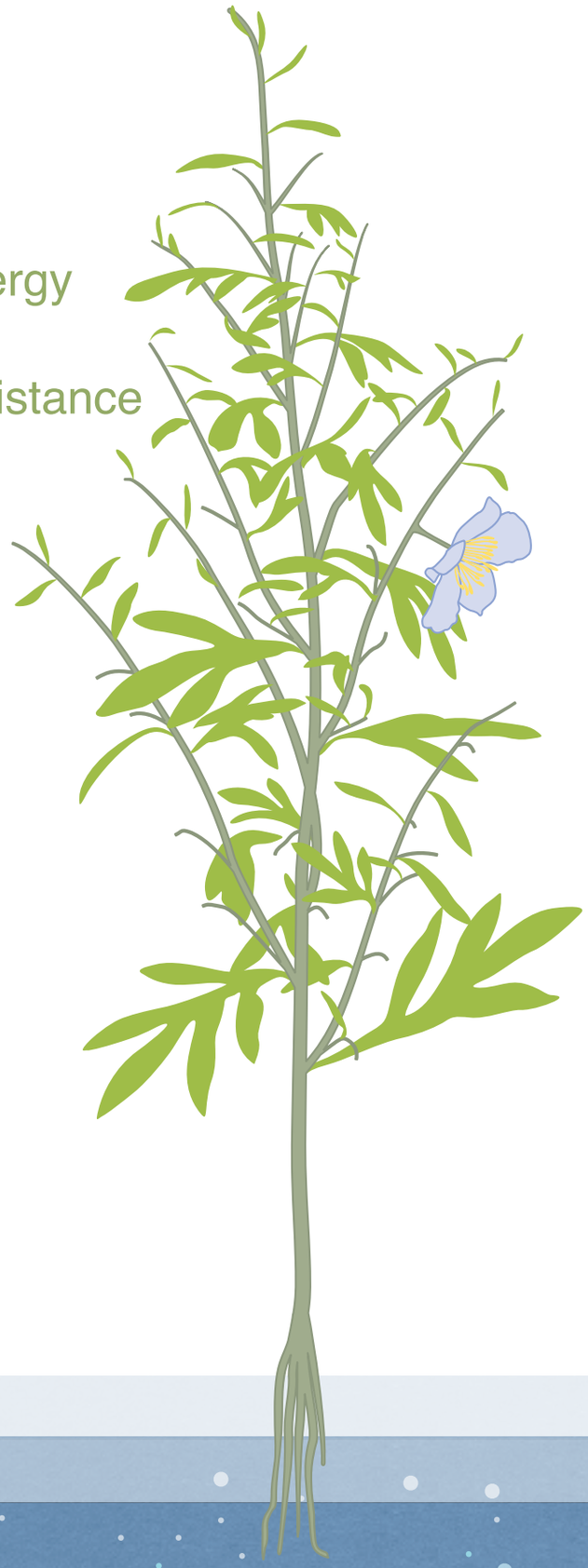
- (N) Nitrogen
  - Biomass
- (P) Phosphorus
  - Flower, fruit & energy
- (K) Potassium
  - Flower, fruit & resistance

## 2nd Macro

- (Ca) Calcium
- (S) Sulfur
- (Mg) Magnesium

## Micro

- (B) Boron
- (Cl) Chlorine
- (Mn) Manganese
- (Fe) Iron
- (Zn) Zinc
- (Cu) Copper
- (Mo) Molybdenum
- (Ni) Nickel



## Measurements

Water

Water level

pH 5,8-6,5

EC

# The light

1000°K
2000°K
3000°K
4000°K
5000°K
6000°K
7000°K
8000°K
9000°K
10 000°K
12 000°K

1500°K Candle light
2200°K High pressure sodium
2700°K Warm white LED
3000°K Halogen (100 W)
4200°K Cool white fluorescent
4000-4500°K Natural white LED
5500-6000°K Day white LED
7000-7500°K Cool white LED
10 000°K Blue sky

## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water
Water level
pH 5,8-6,5
EC

PAR - Photosynthatically active radiation

Flower
Fruit

1000°K
2000°K
3000°K
4000°K
5000°K
6000°K
7000°K
8000°K
9000°K
10 000°K
12 000°K

1500°K Candle light
2200°K High pressure sodium
2700°K Warm white LED
3000°K Halogen (100 W)
4200°K Cool white fluorescent
4000-4500°K Natural white LED
5500-6000°K Day white LED
7000-7500°K Cool white LED
10 000°K Blue sky

## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water
Water level
pH 5,8-6,5
EC
PAR

Flower
Fruit

1000°K
2000°K
3000°K
4000°K
5000°K
6000°K

1500°K Candle light
2200°K High pressure sodium
2700°K Warm white LED
3000°K Halogen (100 W)
4200°K Cool white fluorescent
4000-4500°K Natural white LED
5500-6000°K Day white LED

Biomass

7000°K
8000°K
9000°K
10 000°K
12 000°K

7000-7500°K Cool white LED
10 000°K Blue sky

## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

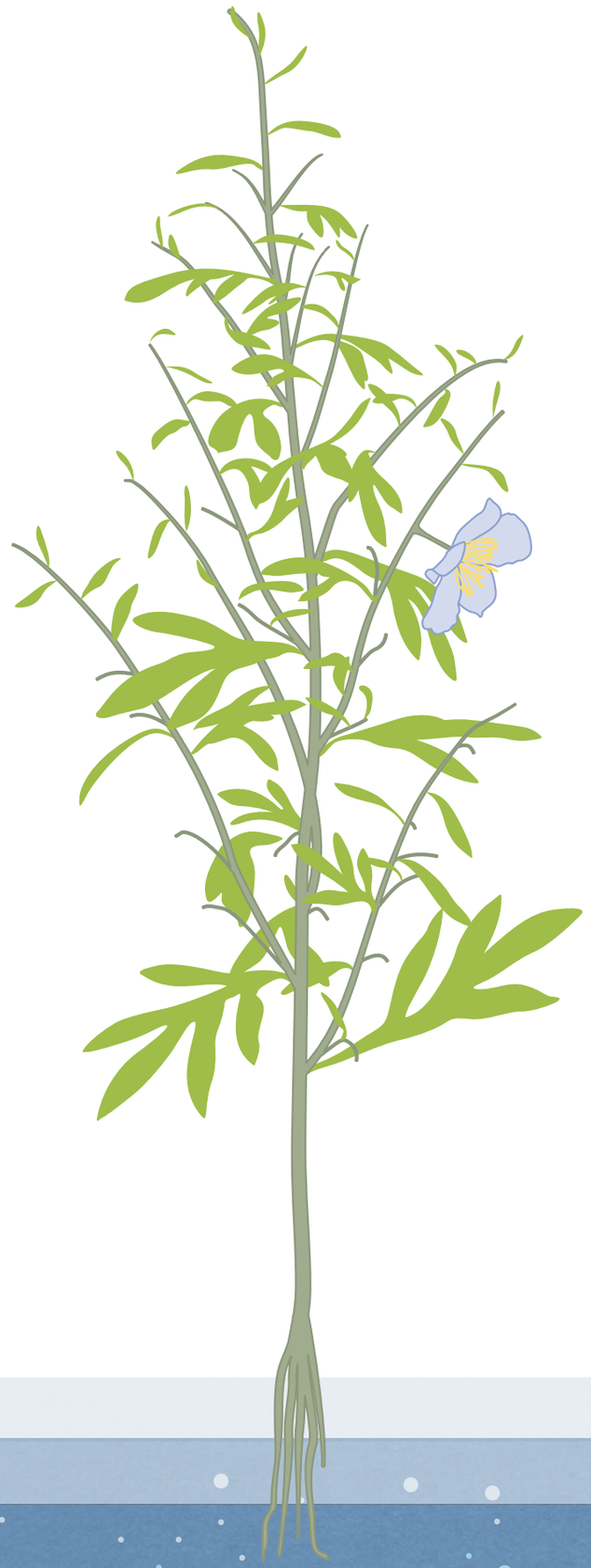
(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water
Water level
pH 5,8-6,5
EC
PAR

# Temp & humidity

Temperature & humidity
Over 12°C



## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water

Water level

pH 5,8-6,5

EC

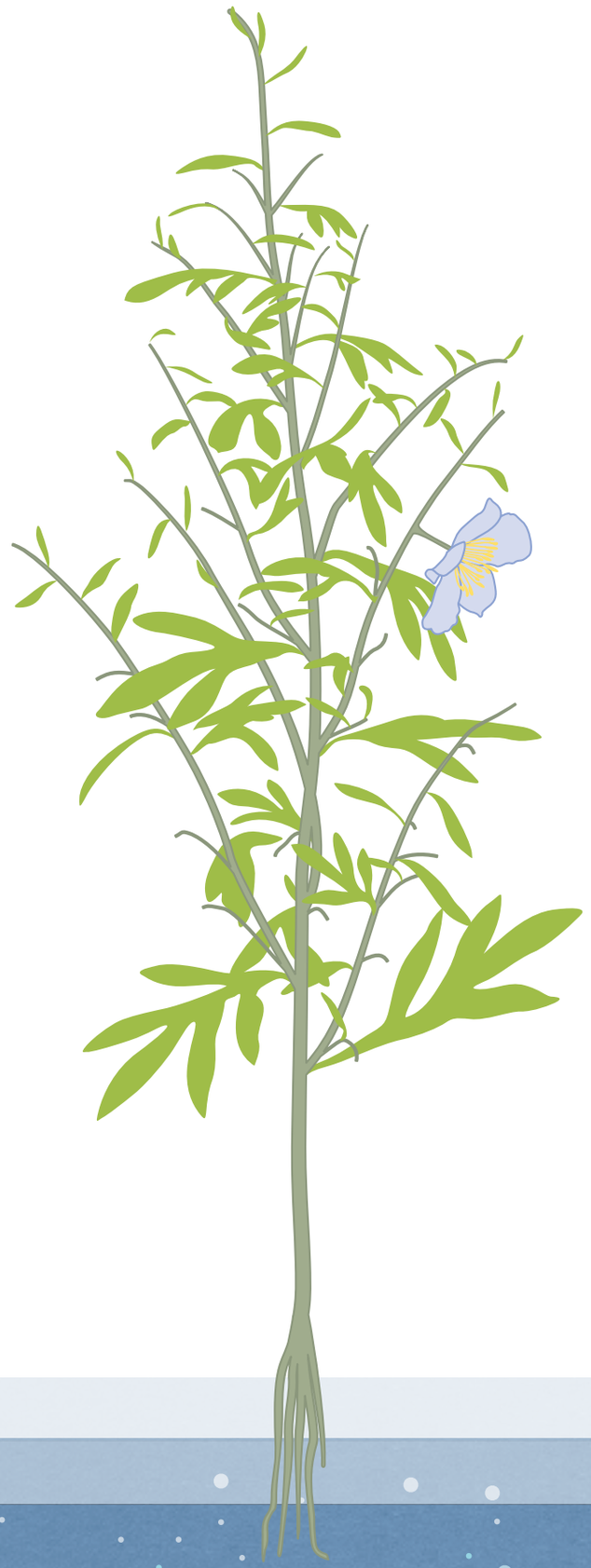
PAR

Color temp

2700-5500°K - Growth

5500-8000°K - Flower & fruit

Temperature & humidity
Over 12°C
30-70%



## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

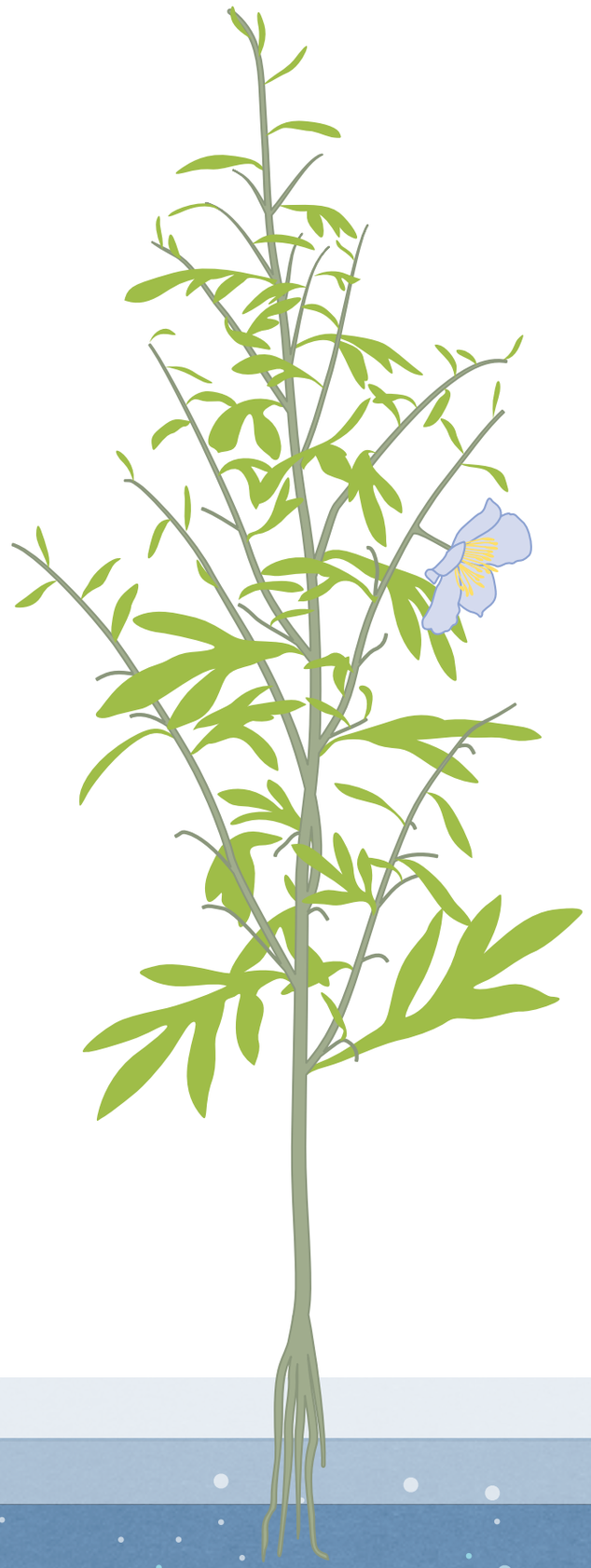
Water

Water level
pH 5,8-6,5
EC
PAR

Color temp

2700-5500°K - Growth
5500-8000°K - Flower & fruit

Temperature & humidity
Over 12°C
30-70%



## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water

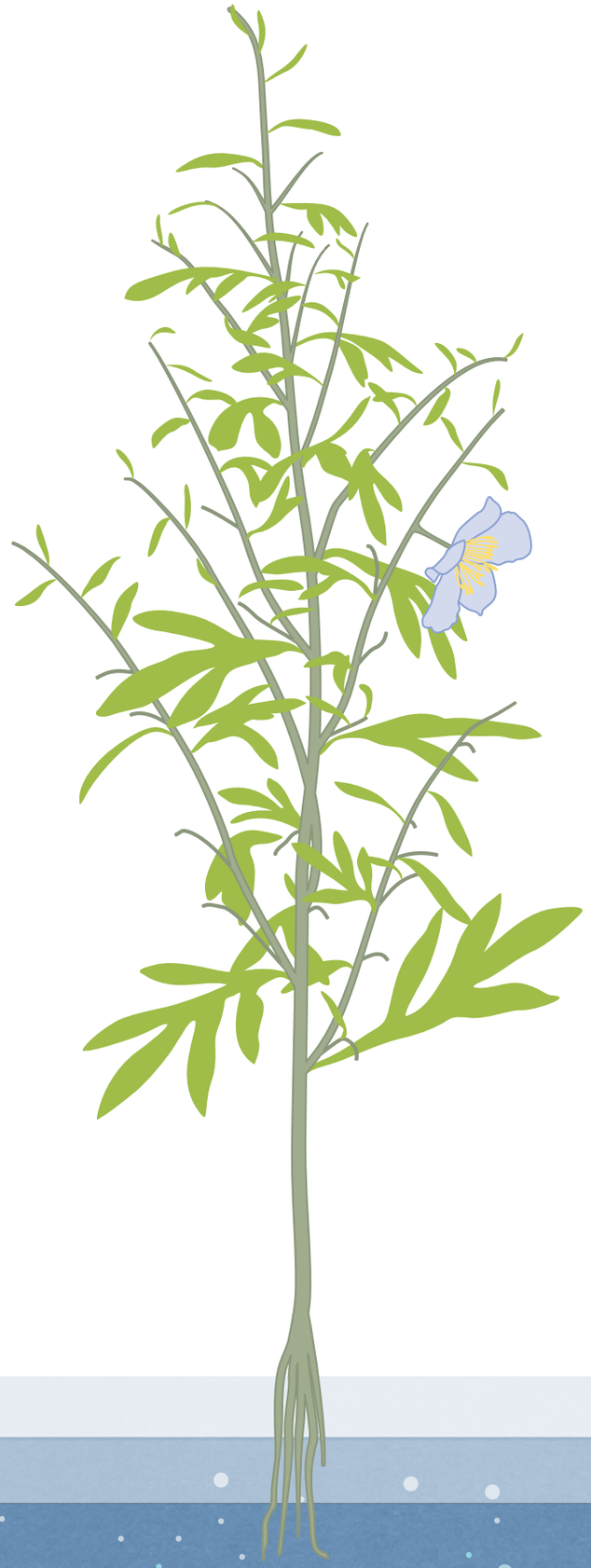
Water level
pH 5,8-6,5
EC
PAR

Color temp

2700-5500°K - Growth
5500-8000°K - Flower & fruit

Temperature & humidity
Over 12°C
30-70%

# OXYGEN



## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

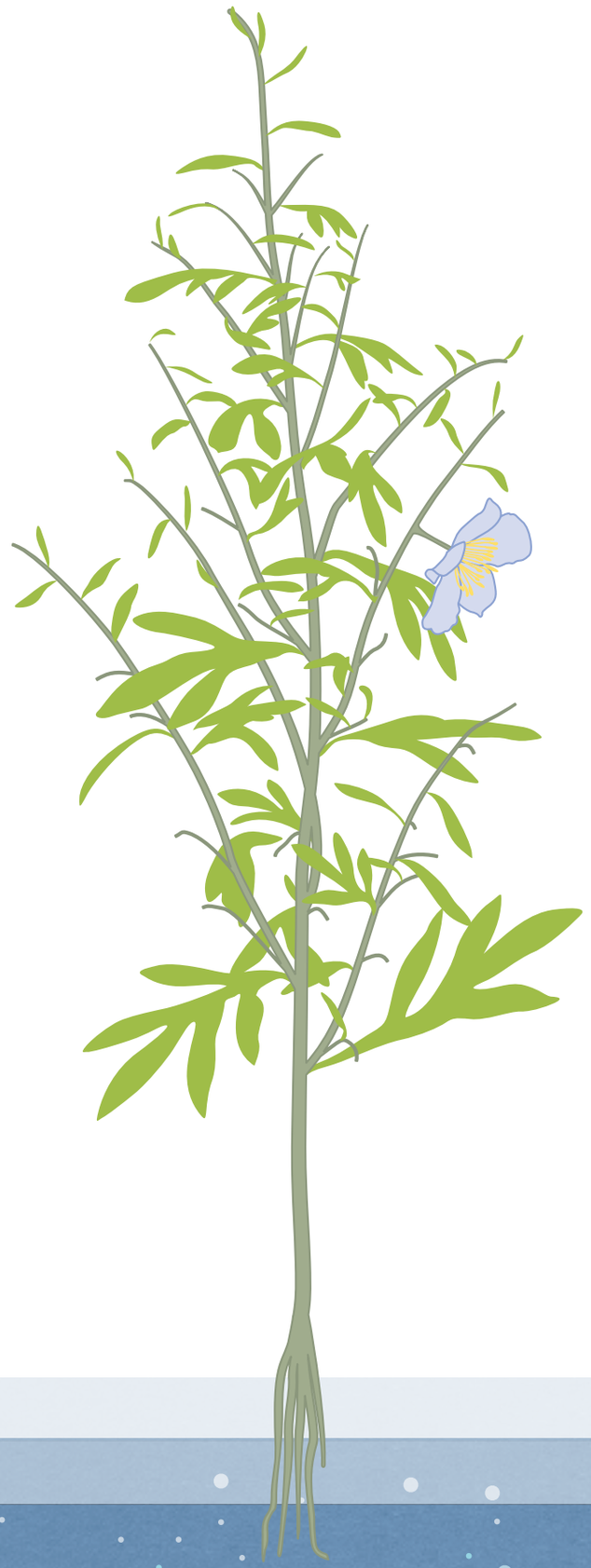
## Measurements

Water

Water level
pH 5,8-6,5
EC
PAR

Color temp

2700-5500°K - Growth
5500-8000°K - Flower & fruit



## Nutrients

Micro

(N) Nitrogen
Biomass
(P) Phosphorus
Flower, fruit & energy
(K) Potassium
Flower, fruit & resistance

2nd Macro

(Ca) Calcium
(S) Sulfur
(Mg) Magnesium

Micro

(B) Boron
(Cl) Chlorine
(Mn) Manganese
(Fe) Iron
(Zn) Zinc
(Cu) Copper
(Mo) Molybdenum
(Ni) Nickel

## Measurements

Water

Water level
pH 5,8-6,5
EC
PAR

Color temp

2700-5500°K - Growth
5500-8000°K - Flower & fruit

Temp & humidity

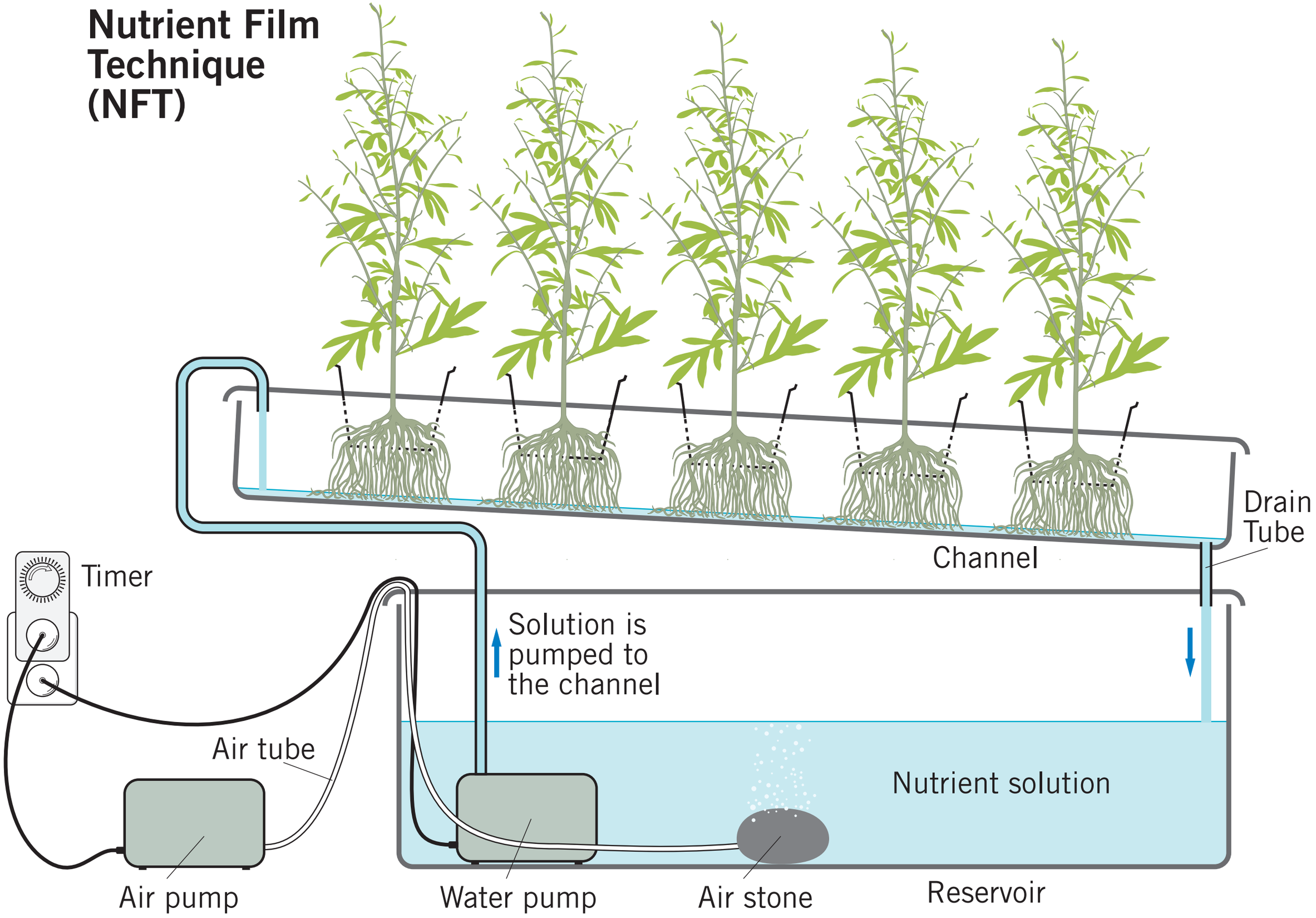
Over 12°C
30-70%

## OXYGEN

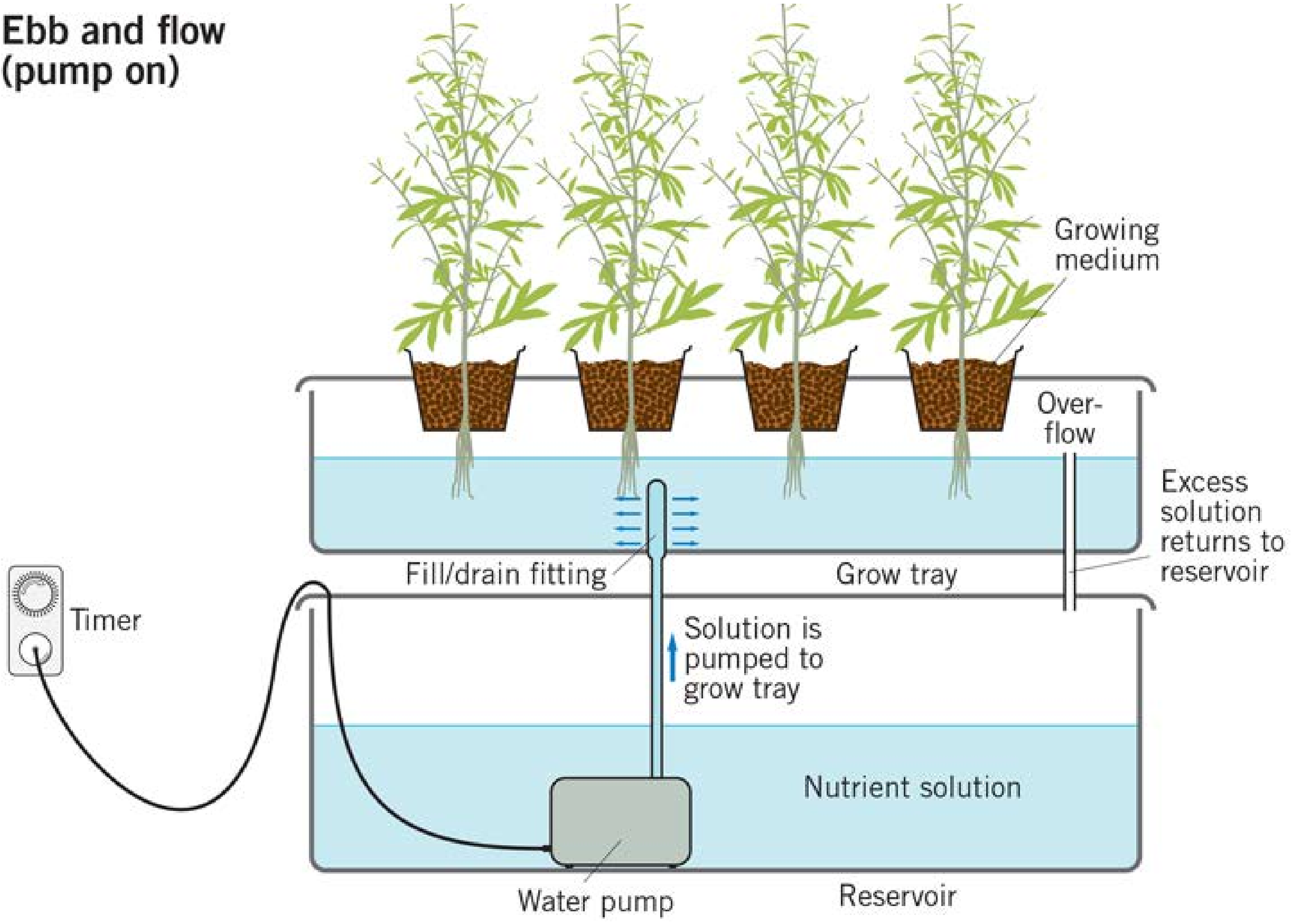
# Choose system

What do you want to grow?

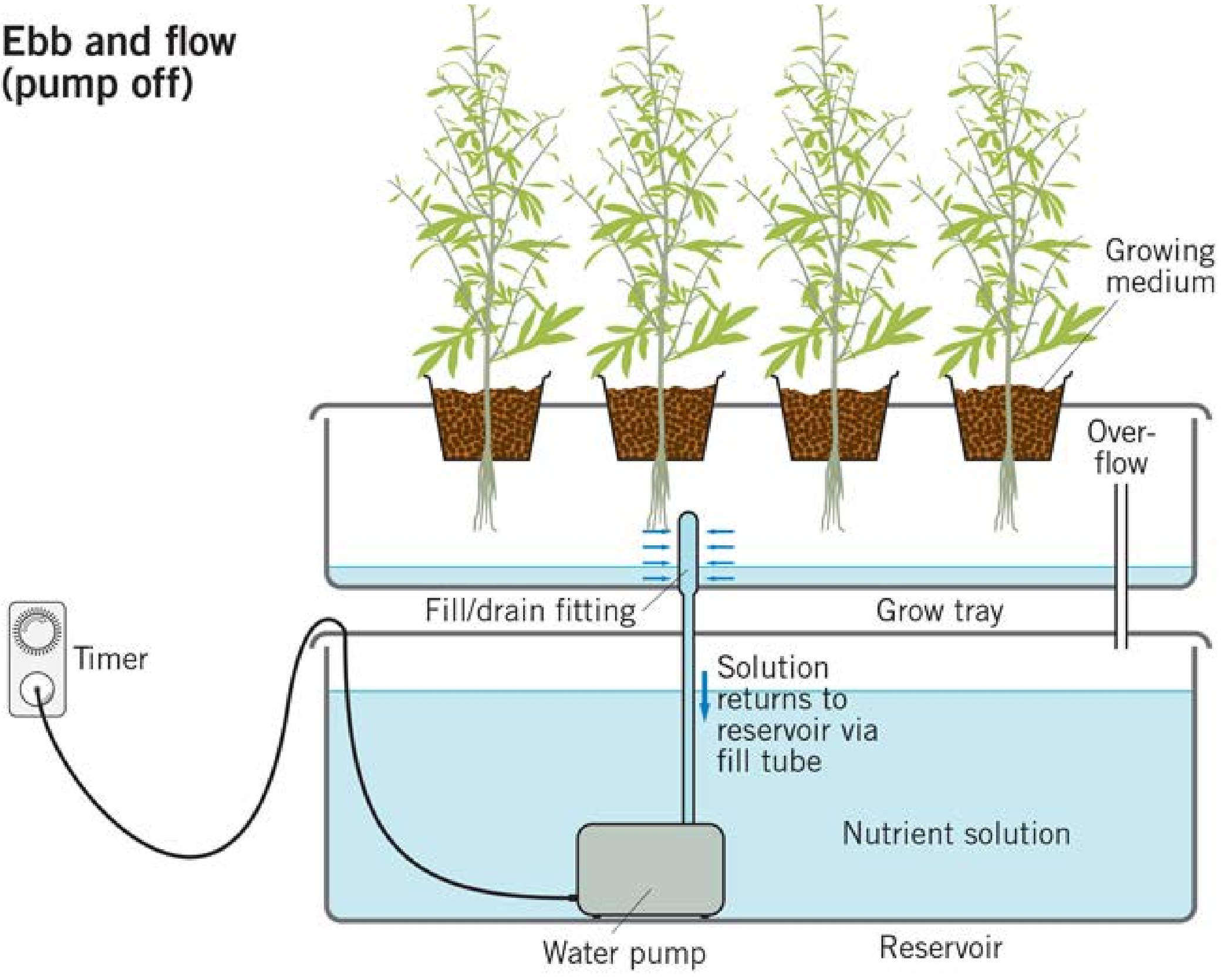
# Nutrient Film Technique (NFT)



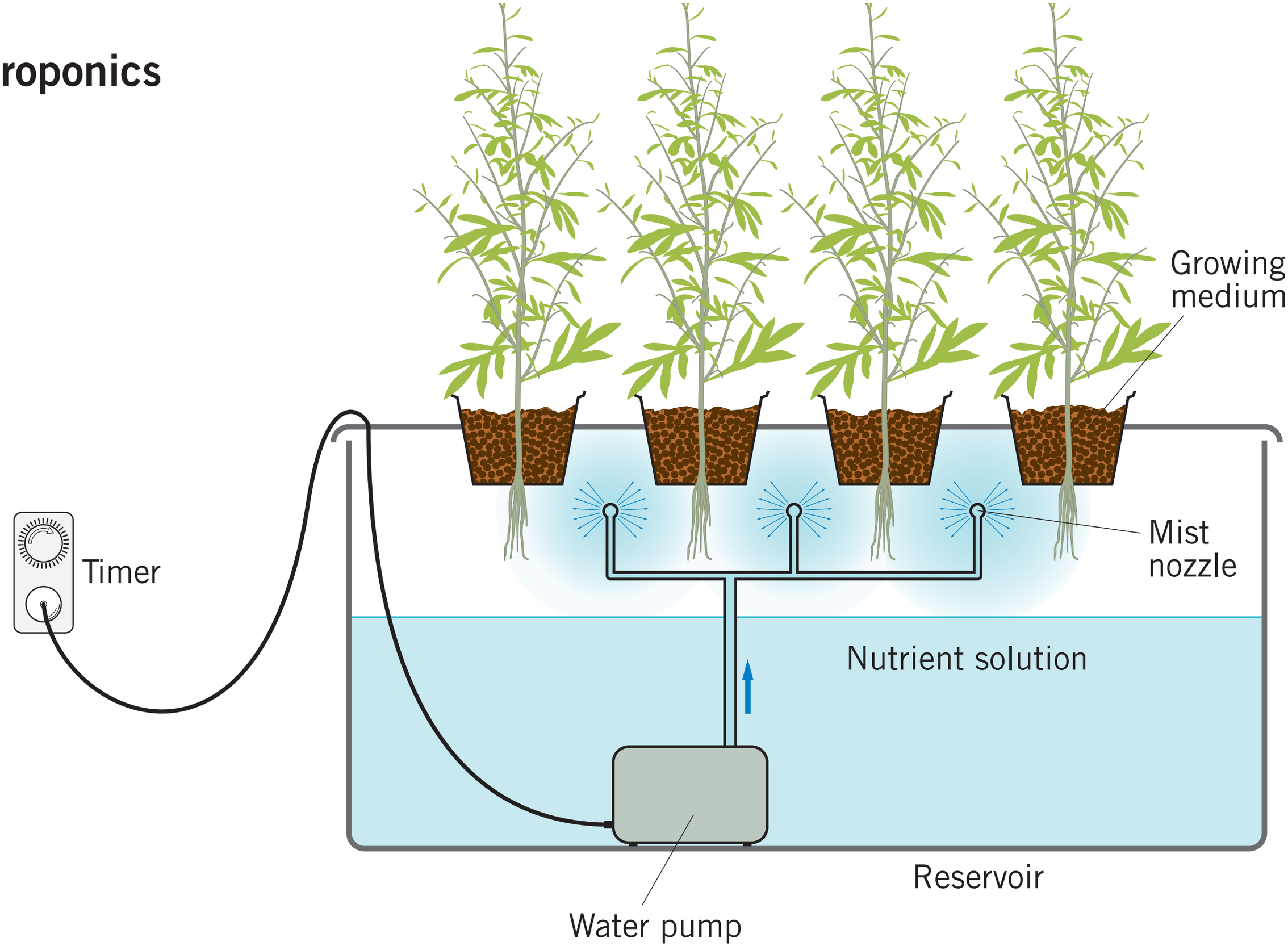
## Ebb and flow (pump on)



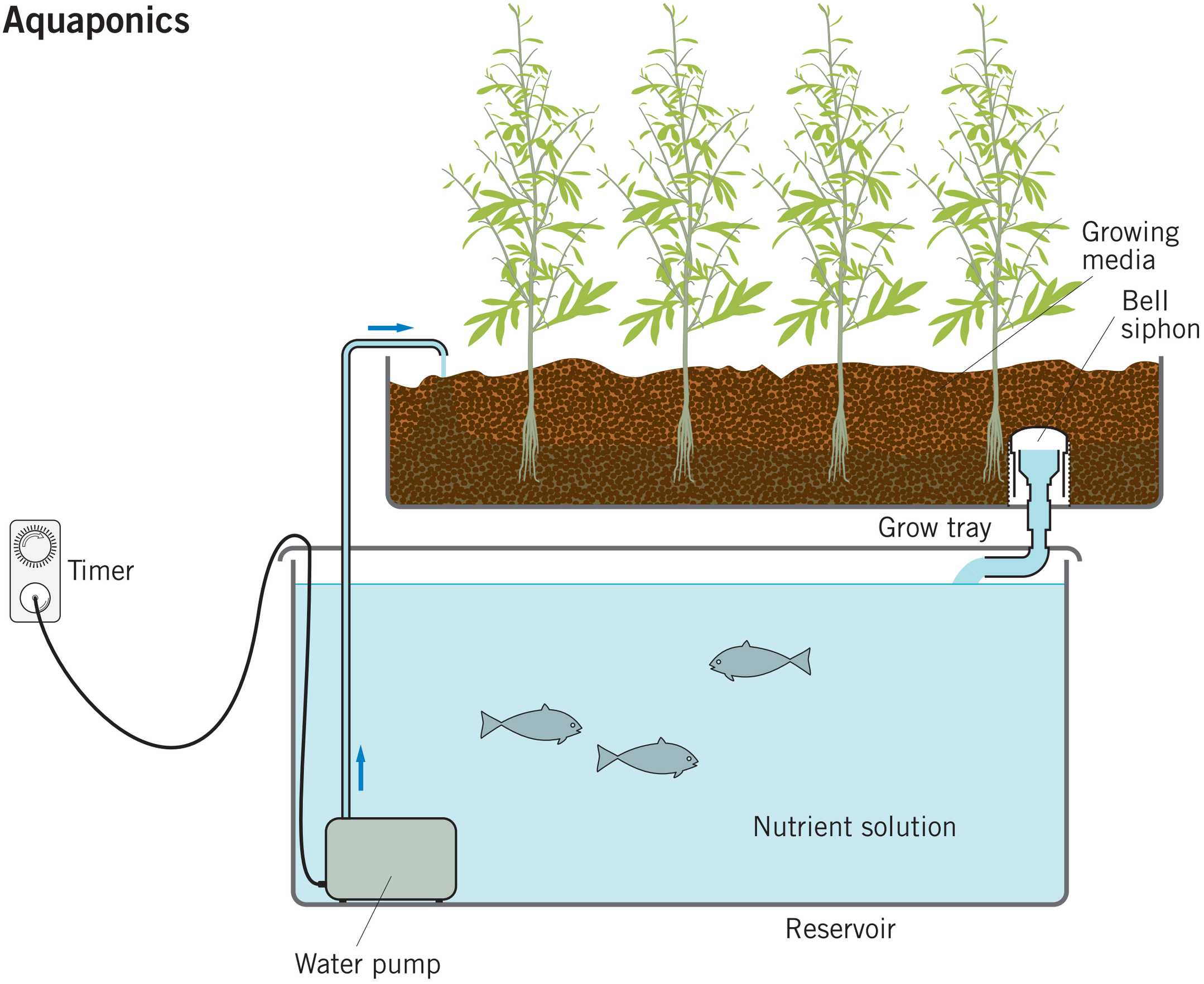
## Ebb and flow (pump off)



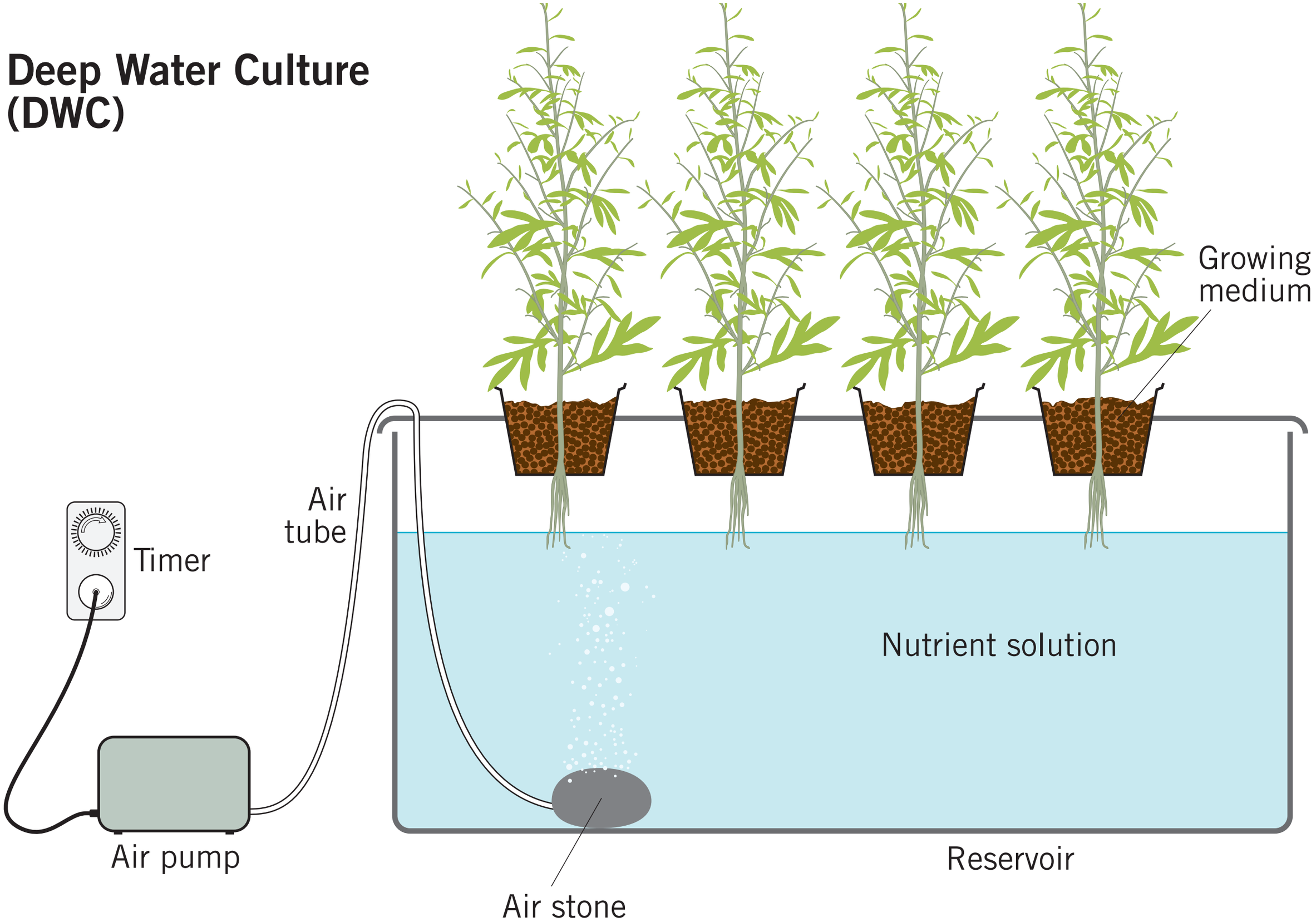
# Aeroponics


Growing medium
Timer
Mist nozzle
Nutrient solution
Reservoir
Water pump

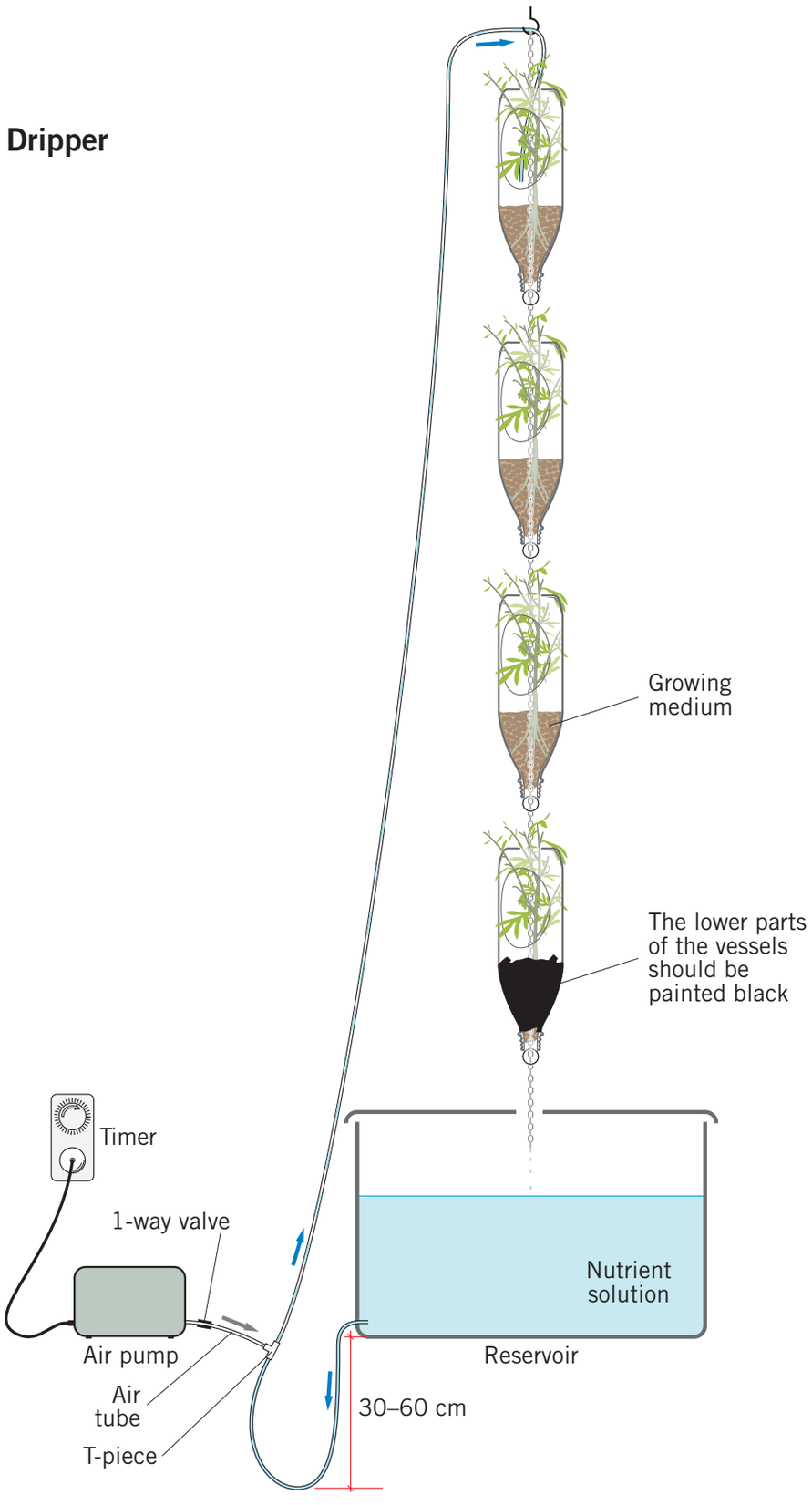
# Aquaponics


Growing media
Bell siphon
Grow tray
Timer
Nutrient solution
Reservoir
Water pump

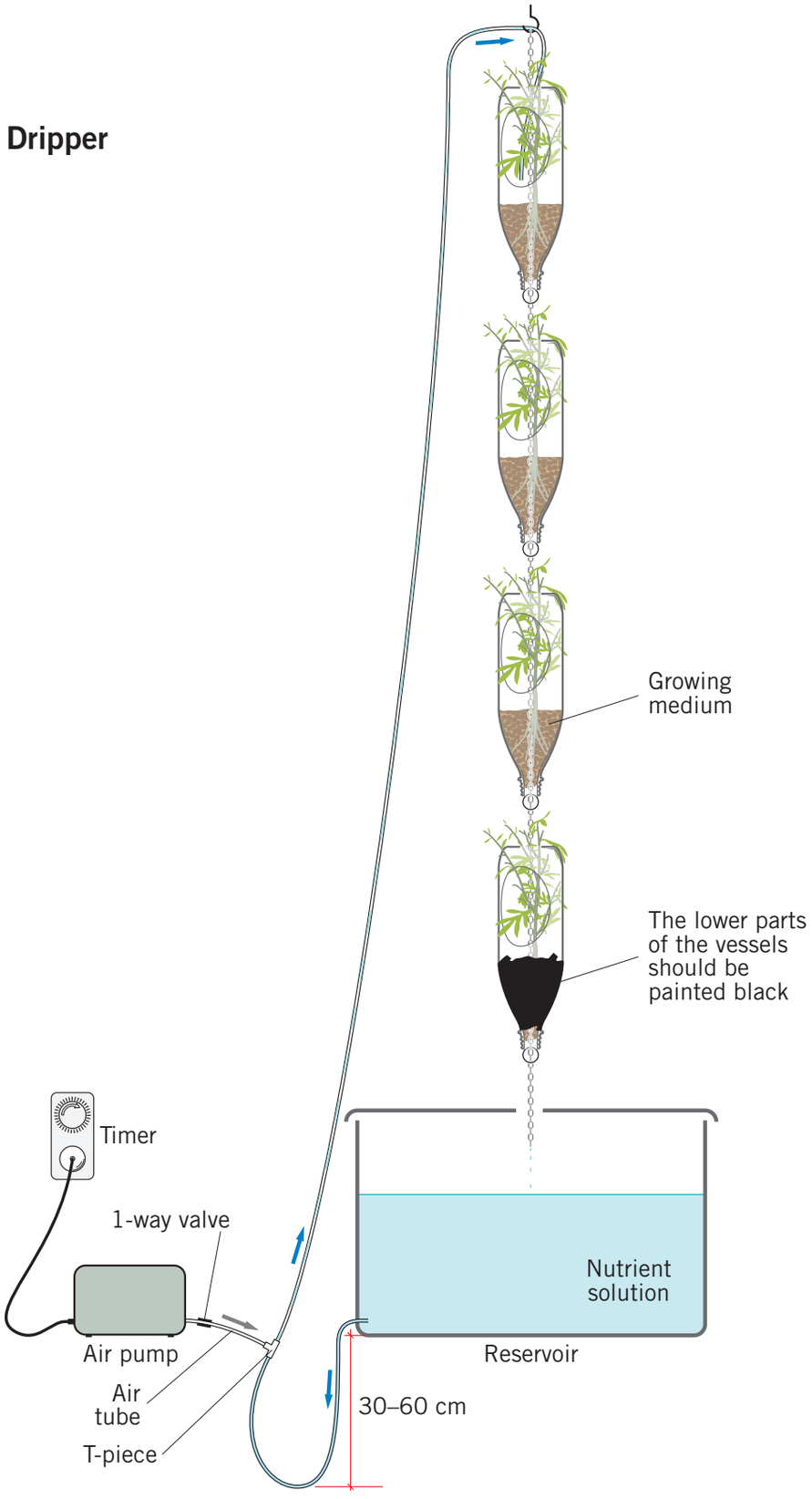
# Deep Water Culture (DWC)



**Dripper**


Growing medium
The lower parts of the vessels should be painted black
Timer
1-way valve
Air pump
Air tube
T-piece
Nutrient solution
Reservoir
30–60 cm

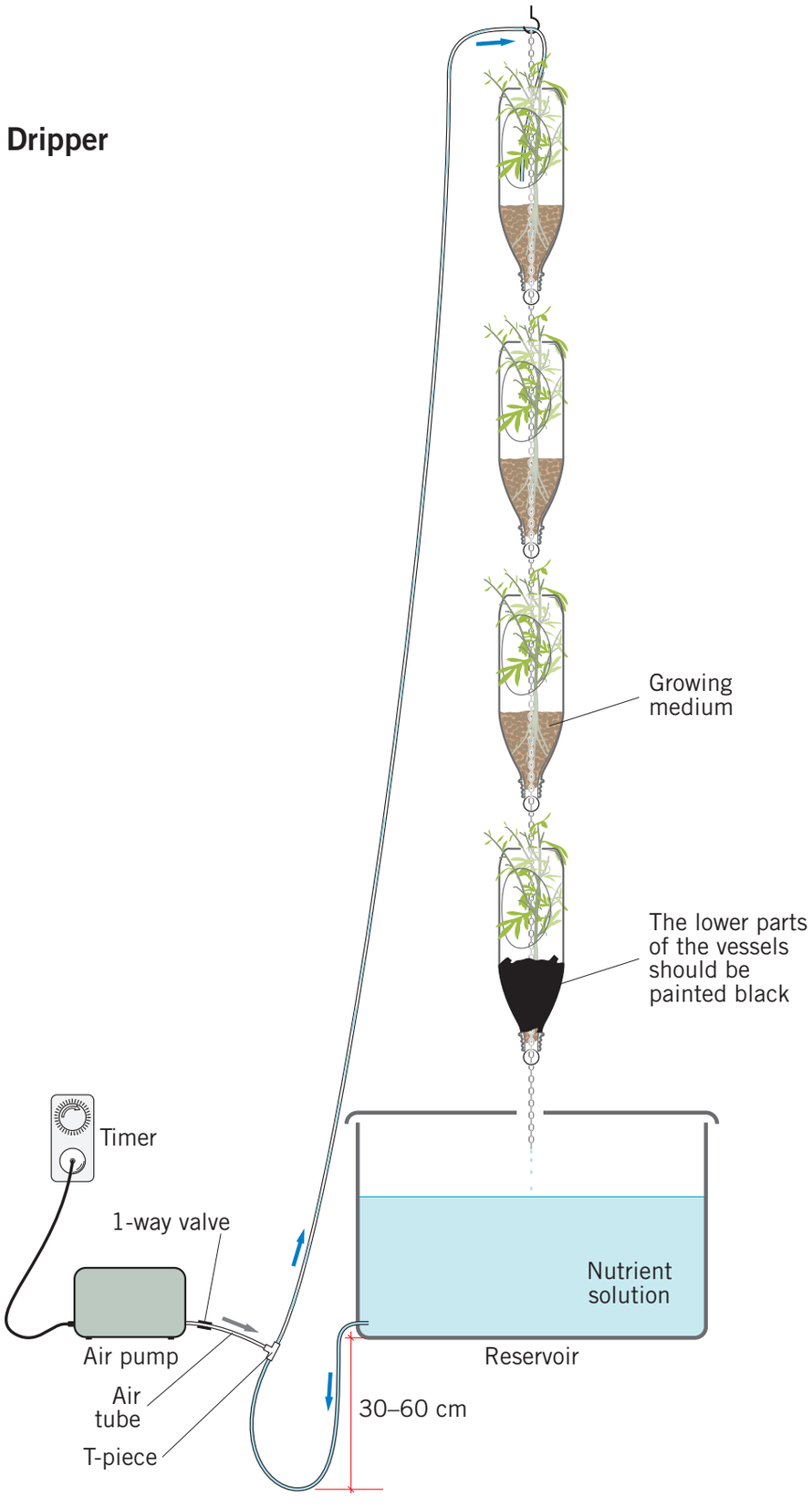
**Dripper**




Growing medium

- Rockwool
- Leca (expanded clay pellets)
- Coconut fiber
- Air
- Water
- Gravel
- Sand
- Perlite
- Vermiculite
- Lava rock
- …

**Dripper**



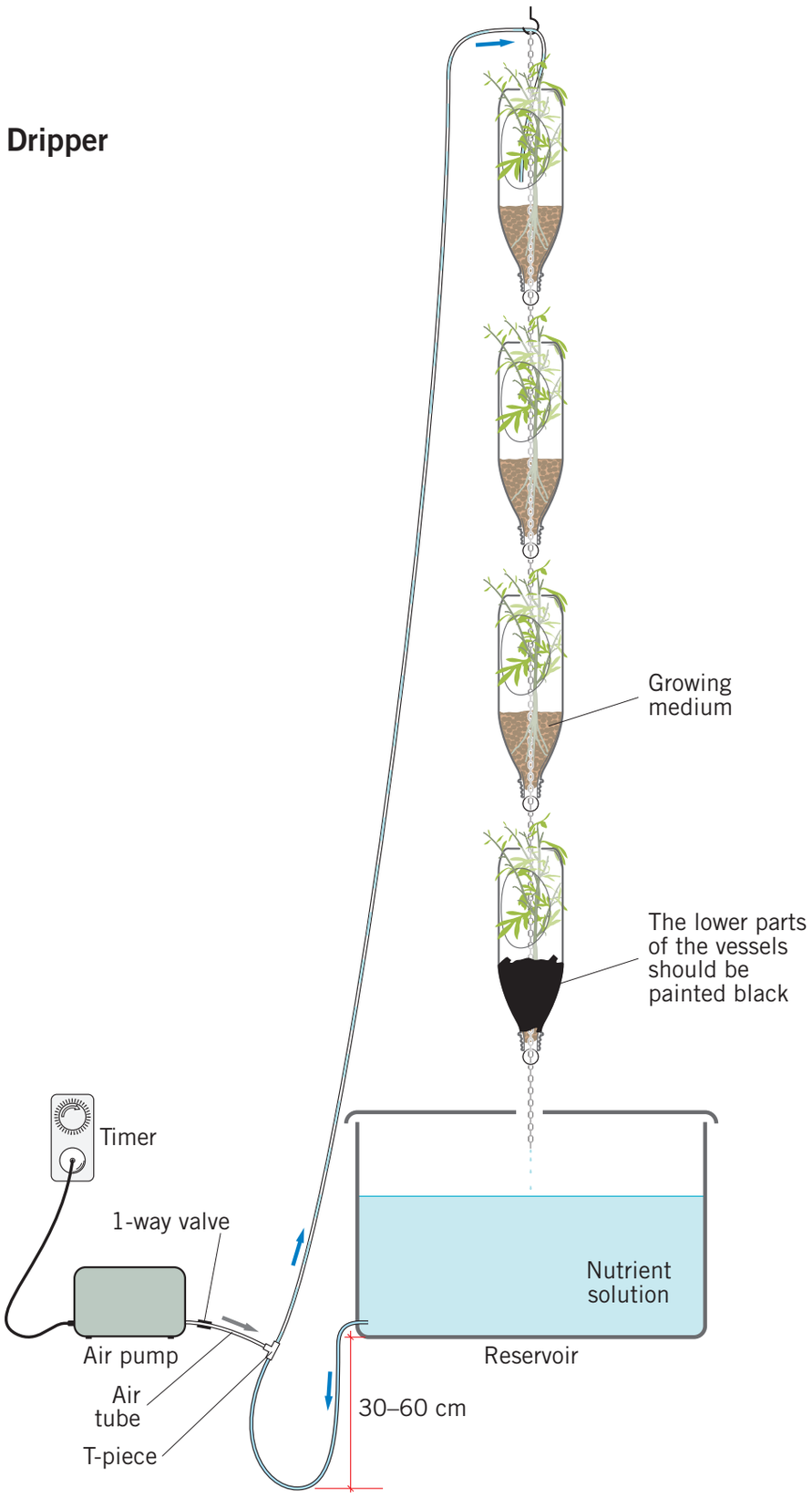

## Parts needed for basic dripper

- PET
- Leca
- Paint
- Chain/rope/…
- Bottle-stoppers (key-rings)
- Reservoir (not transparent)
- Top-hat grommet
- Hose (not transparent)
- Pump
- Timer
- One way valve
- 1 T-connector
- Plants
- Nutrients

## Growing medium

- Rockwool
- Leca (expanded clay pellets
- Coconut fiber
- Air
- Water
- Gravel
- Sand
- Perlite
- Vermiculite
- Lava rock
- …

**Dripper**




# Growing medium

Rockwool
Leca (expanded clay pellets
Coconut fiber
Air
Water
Gravel
Sand
Perlite
Vermiculite
Lava rock
…

# Parts needed for basic dripper

PET
Leca
Paint
Chain/rope/…
Bottle-stoppers (key-rings)
Reservoir (not transparent)
Top-hat grommet
Tube (not transparent)
Pump
Timer
One way valve
1 T-connector
Plants
Nutrients

# Current status on automation

## Billie Bricks - HydroponicController - Arduino

Thread - http://forum.arduino.cc/index.php?topic=130344.0
The code - https://github.com/BillieBricks/Billie-s-Hydroponic-Controller/blob/master/HydroponicControllerV1.1.0
The thing in action - https://www.youtube.com/watch?v=bbRGrWuBp-Y&feature=channel&list=UL

# Let’s build!

All slides and additional info available on:

Questions are welcome at:

Thanks!

@hjartats
@planteringsnormen
@boodlaren
alice@bulukin.se