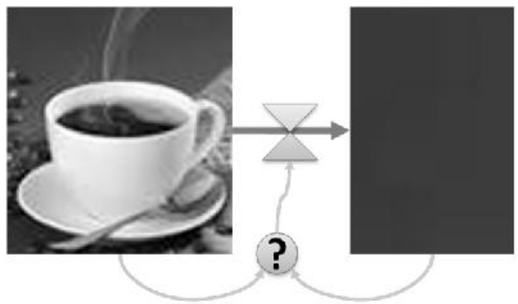
LECTURE 10: CONCEPTUAL MODEL



How a system works

Imagination is more important than knowledge, Albert Einstein

LECTURE OUTCOMES

After mastering the lecture materials at the end of the lecture, students should be able

1. to explain and develop conceptual model
2. to apply conceptual model to cooling coffee
3. to explain the cooling process of hot coffee placed on a table at room temperature
4. to generate equations to describe the temperature change of cooling coffee

LECTURE OUTLINE

1. INTRODUCTION
   - Definition
   - Conceptual diagrams
2. EXAMPLES OF CONCEPTUAL MODELS
   - A Conceptual Model of GPA
   - Leaf:Truss Ratio in Tomato
   - **Plant Growth**
3. NEWTON'S LAW OF COOLING
   - Coffee Case
   - Rate of Cooling
   - Time of Death

1. INTRODUCTION

Definition

What are conceptual models?

- **Conceptual models** are
  concise and visually-stimulating **illustrations** that use symbols or drawings
  to depict the **important features**, **processes** and **management challenges** in a particular environment
- This is accomplished using the most current knowledge or understanding of that particular environment and is presented in a way that is easy to understand
  - Conceptual models should evolve in tandem with knowledge as it is expands with research developments.

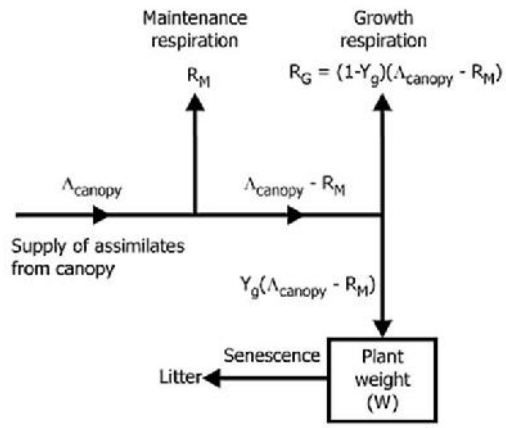
- Conceptual diagrams are useful as these
  1. **Facilitate communication**. Conceptual models are a tool through which detailed technical concepts can be summarised in a non-technical way, and presented to end users such as environmental managers and other coastal zone stakeholders.

  2. **Integrate knowledge across disciplines**. Conceptual models provide a physical background upon which the understanding derived from various scientific disciplines (e.g. ecology, chemistry and geology) can be integrated with the perspectives of other stakeholder groups for addressing management issues.

  3. **Increase understanding**. Conceptual models help users to understand the often complex processes in a system (e.g. how things work, what drives these things and major impacts) and demonstrate the links between them.
  4. **Identify knowledge gaps**. Conceptual models can help users to identify any gaps in scientific understanding, monitoring or natural resource management plans.
  5. **Help with decision making and planning**. Conceptual models can assist environmental/natural resource managers and stakeholders in developing coastal waterway management plans and prioritise research and monitoring efforts.
  6. **Facilitate participation**. Conceptual models can facilitate participation of stakeholders, and assist with interaction between different stakeholder and government groups.

2. EXAMPLES OF CONCEPTUAL MODELS

The most widely used Conceptual model of plant respiration because its simplicity



Conceptual Model of Global Change Factors and Wetlands

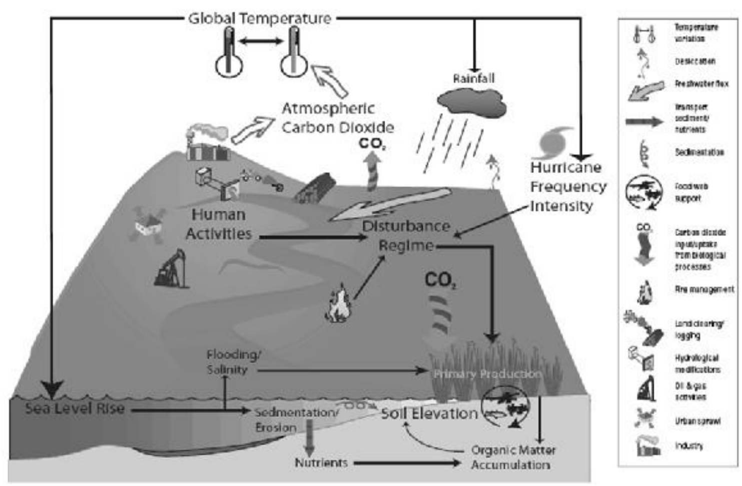
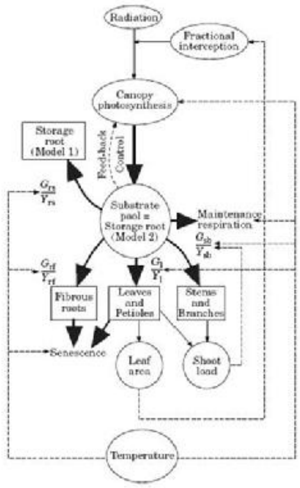


Figure . Conceptual Model of Global Change Factors and Wetlands. Diagram showing how changes in atmospheric CO2 and other global and local factors may impact coastal wetlands. Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols), University of Maryland Center for Environmental Science (http://www.nwrc.usgs.gov/factshts/2006-3074/2006-3074.htm)

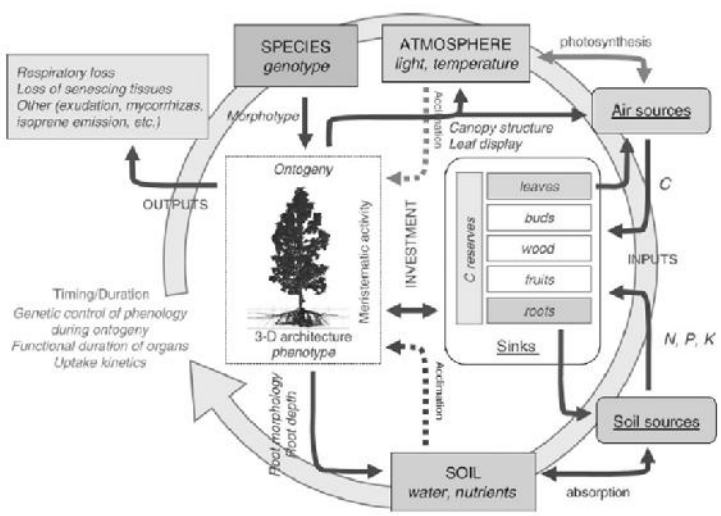
CONCEPTUAL MODEL

The large black arrows show the flux of carbon from canopy photosynthesis into the substrate storage pool from where it is partitioned into leaves, petioles, stems, branches, fibrous roots and storage roots.



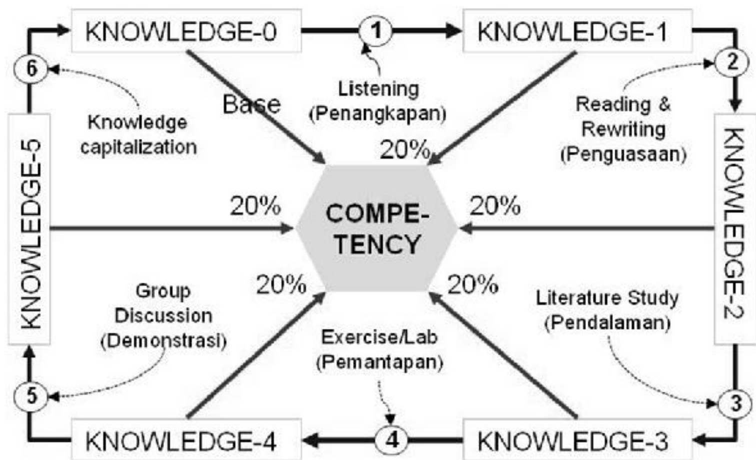
Models 1 and 2 differ only with respect to their relationship to the substrate pool.
In Model 1: the flux of assimilate into the storage root compartment depends on the value of G_{rs}/Y_{rs}

Model 2: the flux of assimilate into the storage root compartment equals the difference between the canopy photosynthesis input into and all the outputs (maintenance respiration, G_l/Y_l, G_{sb}/Y_{sb}, G_{rf}/Y_{rf}) from the substrate storage pool.

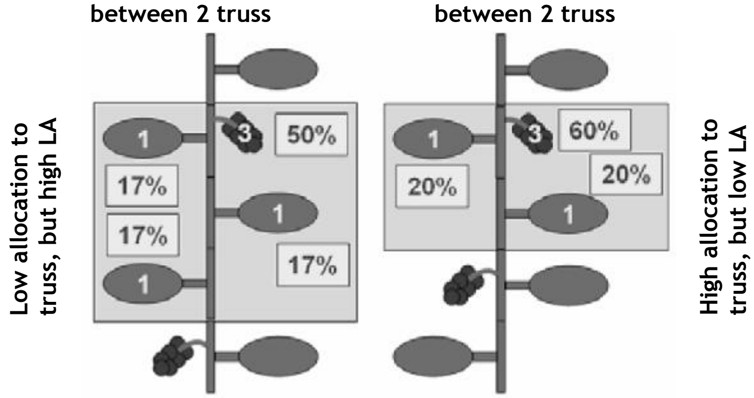


A schematic representation of interactions between a plant and its environment, based on space/architecture and timing/duration components (Fourcaud et al., 2008)

- A Conceptual Model of competency



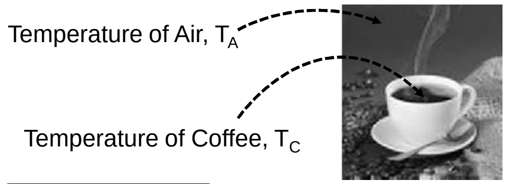
Leaf: Truss ratio in Tomato

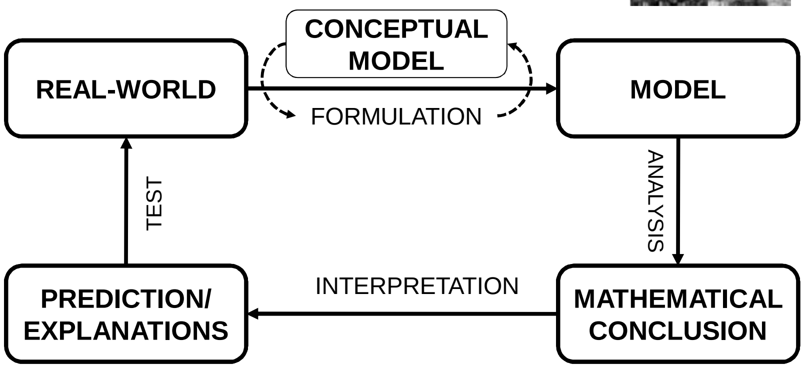


Schematic presentation showing the effect of leaf:truss ratio on assimilate partitioning between leaves and trusses in tomato. Numbers inside organs represent sink strength for a specific day. Percentages represent partitioning on that day, resulting from these sink strengths (Heuvelink et al., 2007)

III. NEWTON'S LAW OF COOLING

COFFEE CASE





Why does the temperature of hot coffee decline with time?, How does it happen

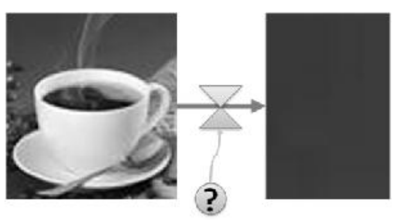
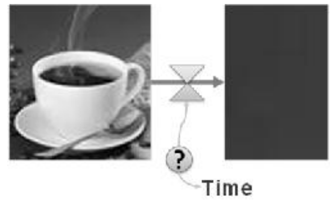
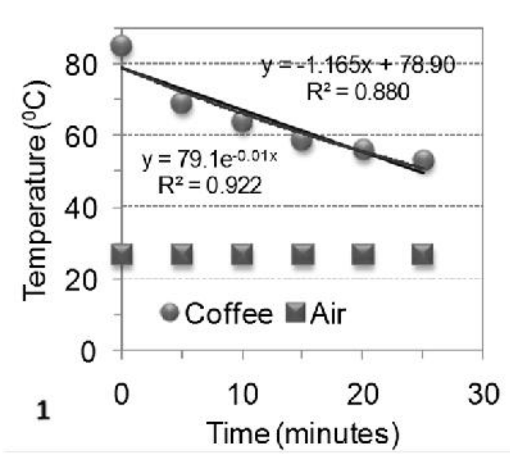


Figure . Conceptual Model of Coffee cooling down with time

Time (minutes, i)	Temperature (^{0}C)			
	Coffee (T_C)	Air (T_A)	T_C-T_A	$\delta T_C = (T_{Ci}-T_{Ci-1})$
0	85	27	58	
5	69	27	42	16
10	64	27	37	5
15	59	27	32	5
20	56	27	29	3
25	53	27	26	3

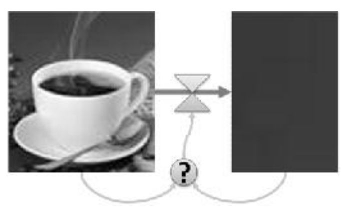
1. Time Factor: Can the decrease in the temperature of hot coffee be explained by time?



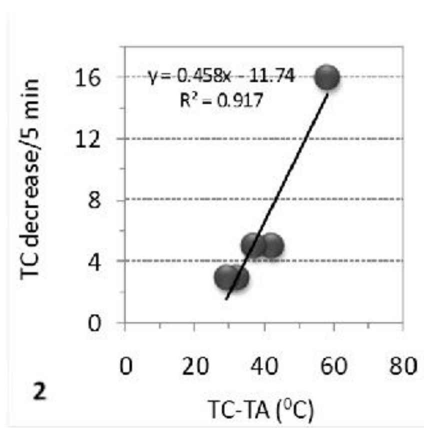


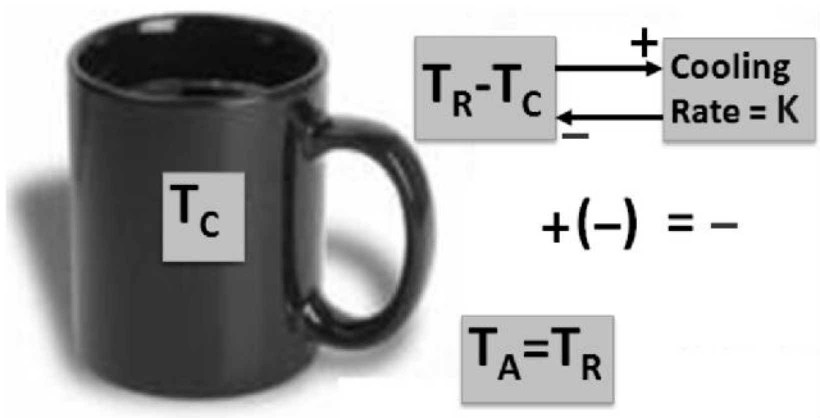
But how does it work? How does the time reduce the temperature of hot coffee?

2. Temperature difference: Is a difference in temperature of Coffee and Air (T_C-T_A) responsible for the temperature decrease ($\delta T_C = T_{Ci}-T_{ci-1}$)?

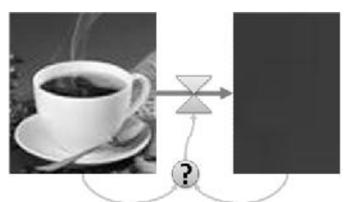


T_C-T_A	¢T_C = (T_{Ci}-T_{Ci+1})
58	16
42	5
37	5
32	3
29	3
26	

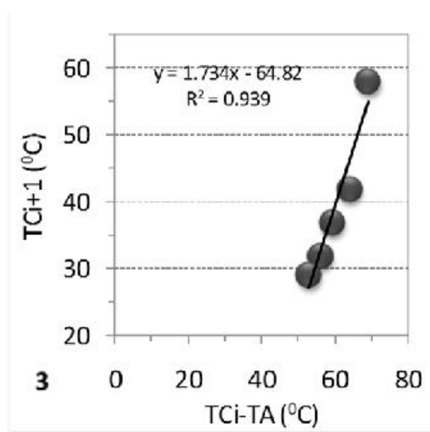




3. Factor of temperature difference: Is the temperature of coffee at time t+1 related to a difference in temperature of Coffee and Air at time t (T_C-T_A)?

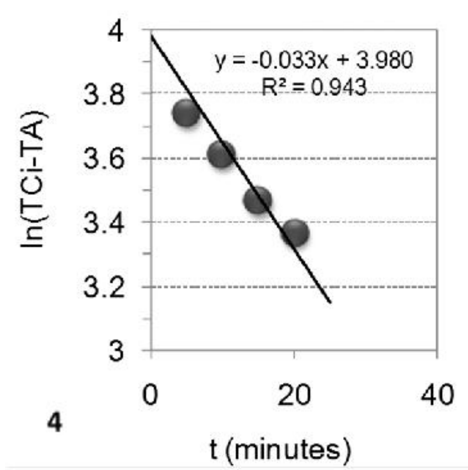


$T_{C\ i+1}$	T_{Ci}-T_A
69	58
64	42
59	37
56	32
53	29



The following approach is based on **$\ln(T_{Ci}-T_A)$** instead of $(T_{Ci}-T_A)$ as used previously

Time	$\ln(T_{Ci}-T_A)$
0	4.06
5	3.74
10	3.61
15	3.47
20	3.37



The last equation shows

- $y = -0.033x + 3.980$; $R^2 = 0.943$
- $y = \ln(T_C-T_A)$
- $\ln(T_C-T_A) = -0.033t + 3.980$
- $\ln(T_C-T_A) = kt + C$
- $(T_C-T_A) = e^{(kt + C)}$
- $T_C-T_A = e^{(-0.0333t + 3.980)}$

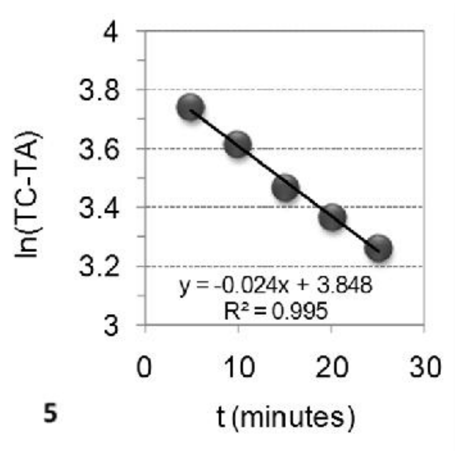
$$\mathbf{T_C = T_A + e^{(kt+C)}}$$

Conclusion

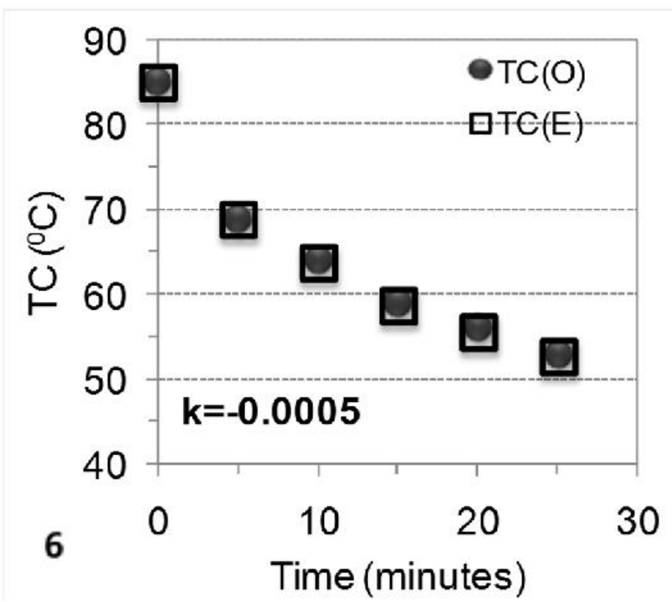
$$T_C = T_A + e^{-0.033t + 3.980}$$

The following approach is based on $\ln(T_{ci+1}-T_A)$ instead of $\ln(T_{Ci}-T_A)$ as used previously

t	T_C-T_A	$\ln(T_{ci+1}-T_A)$
5	58	3.738
10	42	3.611
15	37	3.466
20	32	3.367
25	29	3.258



5



6

A better relationship was found as follows

- $y = -0.0241x + 3.8488; R^2 = 0.9952$
- $y = \ln(T_{ci+1}-T_A)$
- $\ln(T_{ci+1}-T_A) = kt + C$
- $\ln(T_{ci+1}-T_A) = -0.0241x + 3.8488$
- $T_{ci+1}-T_A = e^{-0.0241t + 3.8488}$

Conclusion

$$T_{ci+1} = T_A + e^{(-0.0241t + 3.8488)}$$

What is a drinkable temperature of coffee

- **Rate of Cooling**
  - ***Rate of cooling of an object is proportional to the temperature difference between an object and its surroundings***
  - What is a drinkable temperature of coffee

$$\frac{\delta T_C}{\delta t} = k(T_C - T_A)$$

$$T(t) = T_A + (T_H - T_A)e^{-(A/(mcR))t}$$

$$T_C = T_A + e^{(kt+C)}$$

Time of Death

- Suppose that a corpse was discovered in a motel room at midnight and its temperature was 80^0F(26.67^0C).
- The temperature of the room is kept constant at 60^0F (15.56^0C).
- Two hours later the temperature of the corpse dropped to 75^0F (23.89^0C).
- Find the time of death.

- Solution
  - Time (t_1) 24.00 $T_C = 26.67^0$C
  - Time (t_2) 02.00 $T_C = 23.89^0$C
  - $t_2 - t_1 = 2$
  - Time 02.00 $T_A = 15.56^0$C
  - **Rate of Cooling**

$$\frac{\delta T_C}{\delta t} = k(T_C - T_A)$$

$$T_{C2} = T_A + (T_{C1} - T_A)e^{-kt}$$

$$\frac{(T_{C2} - T_A)}{(T_{C1} - T_A)} = e^{-k(t_2 - t_1)}$$

$$\frac{\delta T_C}{(T_C - T_A)} = k\delta t$$

$$\int_{C_1}^{C_2} \frac{\delta T_C}{(T_C - T_A)} = k\delta t$$

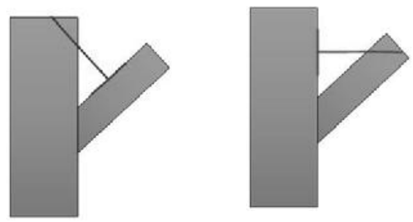
$$\ln\left(\frac{T_{C2} - T_A}{T_{C1} - T_A}\right) = kt$$

$$k(t_2 - t_1) = -\ln\left[\frac{(T_{C2} - T_A)}{(T_{C1} - T_A)}\right]$$

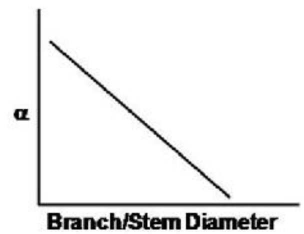
- $k(t_2\text{-}t_1 = 2) = -\ln((23.89^0C - 15.56^0C)/(26.67^0C - 15.56^0C))$
- $2k = -\ln(8.33^0C/11.11^0C) = -\ln(0.7498)$
- 2k = 0.288
- **k = 0.144**

- $(t_2\text{-}t_1) = 1/k[-\ln((26.67^0C - 15.56^0C)/(37^0C - 15.56^0C))]$
- $(t_2\text{-}t_1) = 1/k(0.657)$
- $t_1 = 0$
- $(t_2\text{-}t_1) = -(1/0.144)*0.657$
- $(t_2\text{-}t_1) = -4.57$ = (4 hours and 0.57*60 = 34 minutes)
- The death happened around 7.26 P.M

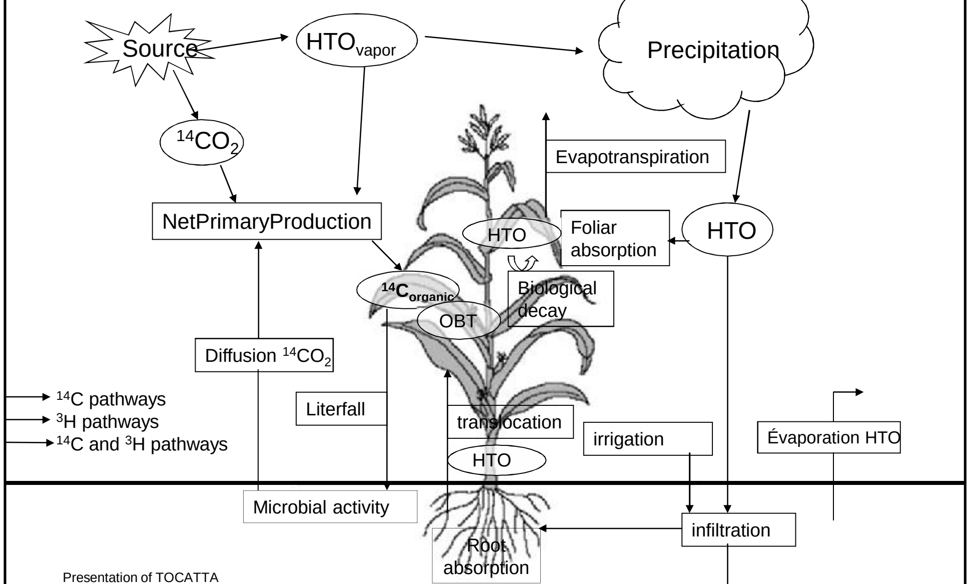
No.	Why a certain thing happens (What is it)	How a system works
1.	A cup of hot coffee cools down with time (why) → Ok & easy to do	
2.	Air temperature under a leaf is lower than that at open space on sunny days → OK & easy to do	
3.	Healthy leaves look green (why) → OK, but not easy to do	
4.	Some fruits look yellow (why) → OK, but not easy to do	
5.	The angle between a branch and stem seems smaller as the ratio of branch/stem diameter increases → OK & easy to do	
6.	An egg cannot stand vertically → OK & easy to do?	
7.	s → OK & easy to do	
8.	s → OK & easy to do	
9.	s → OK & easy to do	
10.	s → OK & easy to do	



Branches that exceed 50% of the stem diameter at point of attachment are more prone to failure and should be …



Plant Growth



Presentation of TOCATTA

EMRAS II, Paris, 09/28/2009