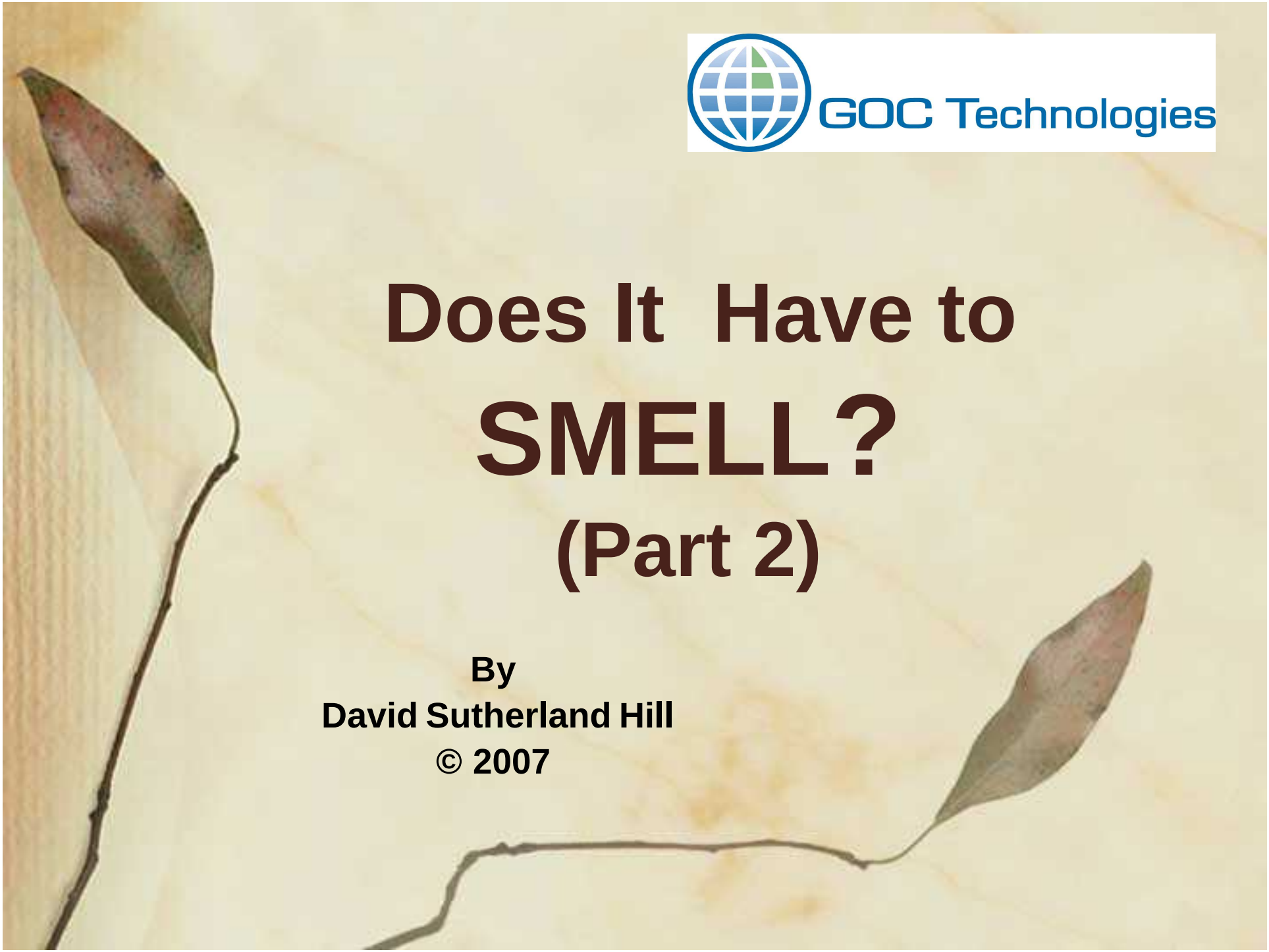


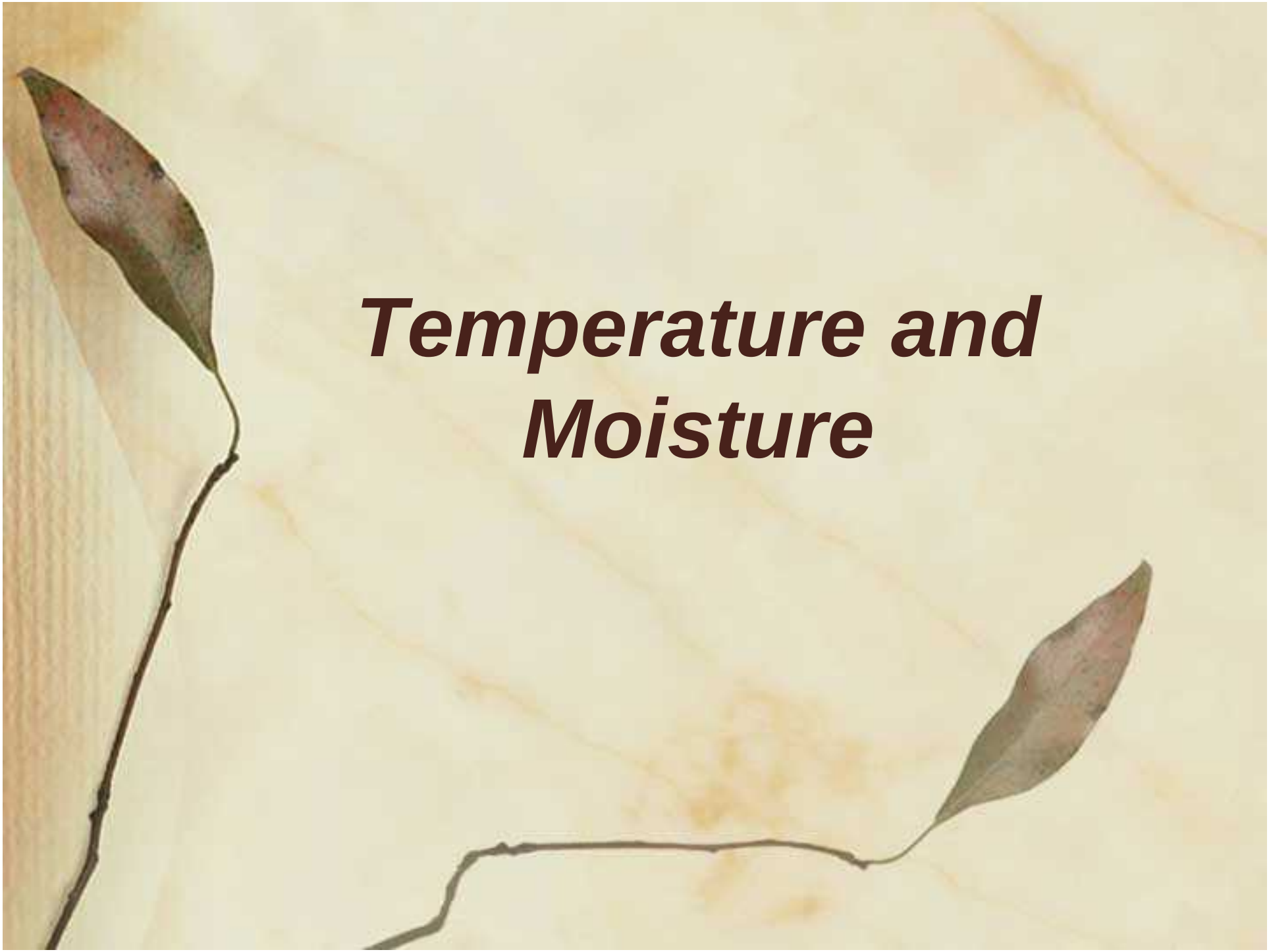
Does It Have to SMELL?

(Part 2)

By
David Sutherland Hill

How Do We Promote Diversity and Quantity of Microbial Populations?

- **Limit temperature spikes**
- **Maintain sufficient moisture levels**
- **Control Energy and Nutrient Supply**
  - **Maintain available Carbon**
  - **Maintain available Nitrogen**
- **Maintain suitable pH levels**
- **Limit tissue damage and relocation**


Temperature and
Moisture

Moisture

- **We all know that bacteria only grow in moisture.**
- **That is why we use deodorant on those areas of our bodies that are most likely to become damp.**
- **Bacteria are present on our arms, our tabletops, our clothes, etc.**

BUT THEY CANNOT GROW !

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Moisture and Temperature

This is because of their unique dependence on moisture to carry them to food and food to them, and on temperature to allow them access to that food.

Consequently

Moisture and temperature levels are critical factors in composting and decomposition.

- **Moisture acts as the medium through which nutrients, essential compounds, enzymes, and wastes are transferred into and out of the bacterium.**
- **Temperature acts as the controlling agent, determining the permeability of the cellular membrane.**

All bacteria have minimum, optimum, and maximum operating temperature requirements .

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Moisture and Temperature

Digestion, and thus growth and reproduction, can only occur in the range from the minimum to the maximum temperature.

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Temperature

- **The *Minimum Temperature* is the lowest surrounding temperature required by a specific species or strain to grow and reproduce.**
- **The *Optimum Temperature* is the surrounding temperature at which a species or strain grows and reproduces the most rapidly.**
- **The *Maximum Temperature* is the highest surrounding temperature at which a specific species or strain can grow and reproduce.**

Temperature

"Surrounding temperature" means temperature in the moisture – not temperature in the air.

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Temperature

- **Below the *Minimum Temperature* the cell wall remains too solid to allow transport of nutrients.**
- **At the *Optimum Temperature* nutrients arrive at the ideal rate for usage by the cell.**
- **Above the *Maximum Temperature* the cell wall is too permeable, and liquid rushes in, filling and expanding the cell until it explodes. (This is the basis of pathogen kill by temperature.)**

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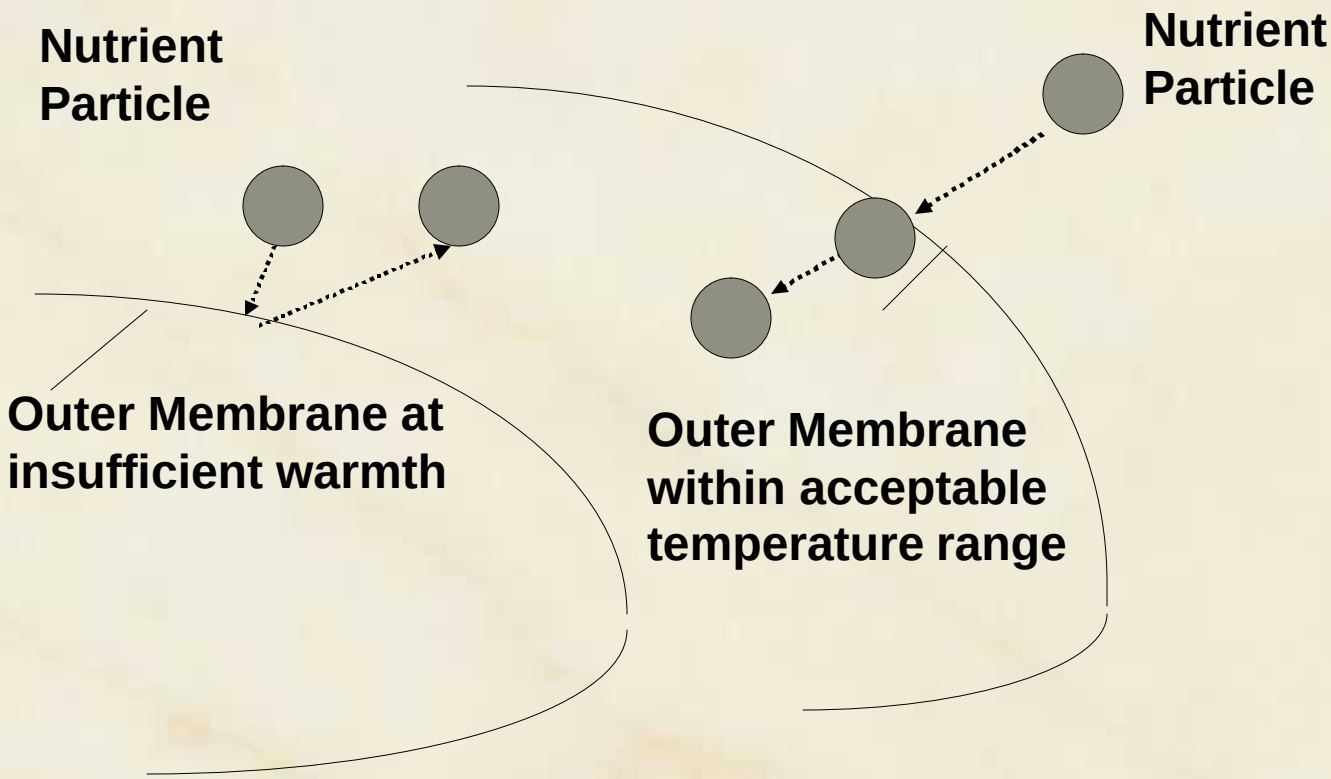
Membrane Permeability



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Temperature and Moisture

This process of transport is the reason bacteria can only grow and reproduce in moisture and at the proper temperatures.

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Microbial Classes by Temperature

	Degrees F	Degrees C
Psychrophylic	**45º to 77º**	**10º to 25º**
Mesophylic	**78º to 104º**	**26º to 40º**
Thermophylic	**105º to 158º**	**41º to 70º**

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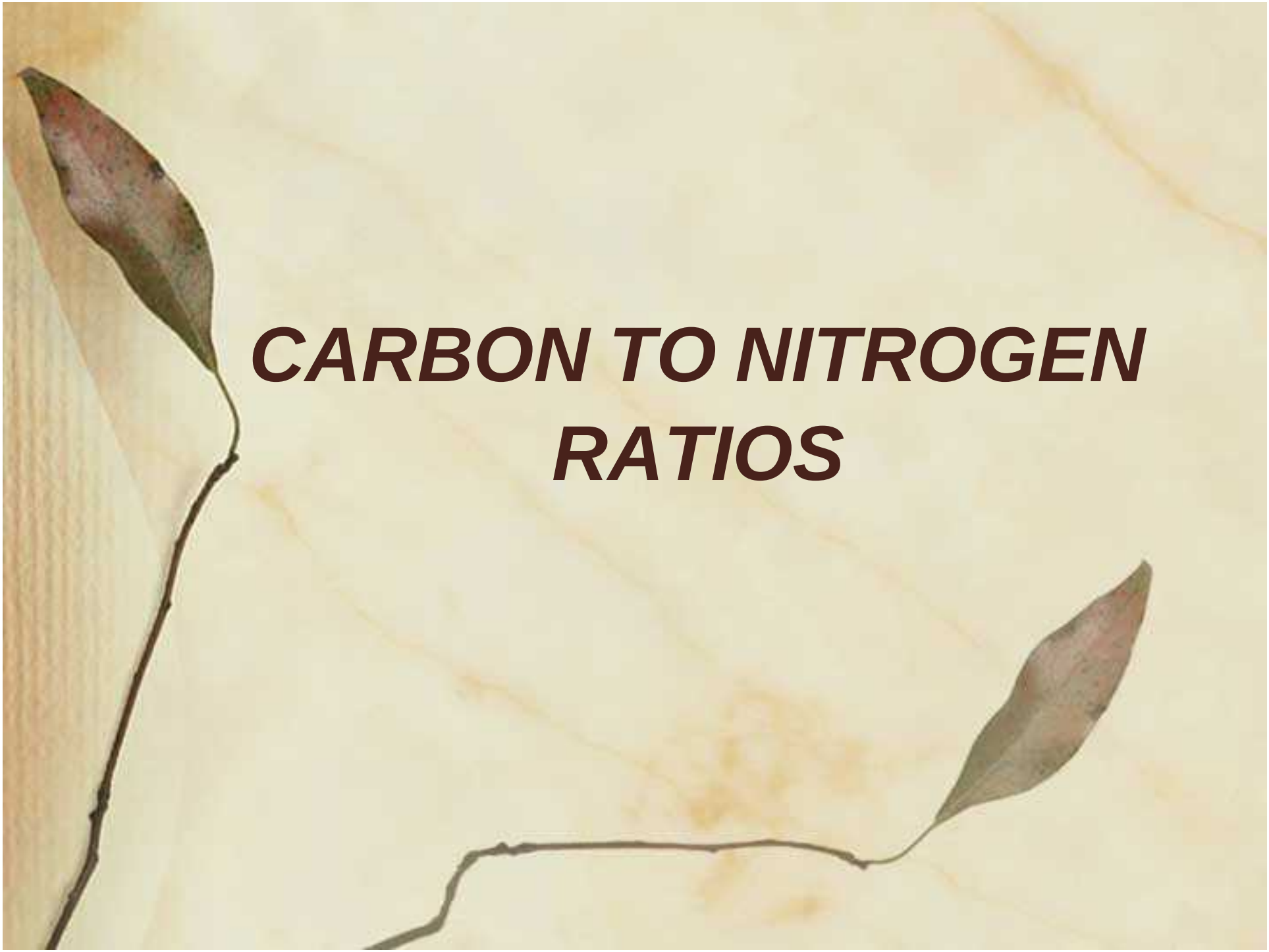
CARBON TO NITROGEN
RATIOS

Types of Carbon

- **Because bacteria only grow in moisture, only SOLUBLE Carbon is available to them!**
- **Because reactions occur outside the cell wall - in the moisture,**

Available Means Soluble!

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C/N Ratio

A minimum ratio of 25 parts available C to 1 part available N is required because

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To Grow and Reproduce, Bacteria Need

- ***At least 15 to 1*** **available C/N to maintain cellular functions, (In other words, just to stay alive.)**
- ***At least 5 to 1*** **available C/N to produce stressor proteins, (proteins that protect them from minor stresses from factors such as pH and salts, temperatures near limits, etc.)**
- ***At least 5 to 1*** **available C/N to support growth and reproduction.**

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Types of Carbon

- **Soluble Non-Volatile : Natural Sugars**
- **Soluble Volatile : Mercaptans, Alkanes, Light Alcohols, others**
- **Insoluble Partial Volatiles : Light Oils**
- **Insoluble Particulate : Cellulose Fibers**
- **Soluble and Insoluble *AE* Matter : Oily Suspensions *A*dsorbed or *E*ntrapped on Silt Particles**

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Types of Carbon

It is essential to understand that the Soluble Volatile Compounds, which contain much of the AVAILABLE CARBON in the compost,

Are also the groups which contain the majority of odorous compounds !

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Types of Carbon

- **Soluble Non-Volatile : Natural Sugars**
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- **Insoluble Partial Volatiles : Light Oils**
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- **Soluble and Insoluble *AE* Matter : Oily Suspensions *A*dsorbed or *E*ntrapped on Silt Particles**

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Turning Unnecessarily

Is a major cause of Odor!

and results in the loss of essential

available Carbon !!

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The Needless Loss of this Carbon

- **Causes more Odor**
- **Limits microbial growth**
- **Limits final organic content of compost**
- **Limits maturity and decomposition rates**
- **Adds Carbon to the atmosphere**

Carbon that SHOULD be in the compost !

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pH, Toxins, and Lack of Feedstock Diversity

Other Factors Negatively Impacting Microbial Diversity and Quantity

1. **pH outside 6.5 to 7.5**
2. **Toxins (may inhibit cellular metabolisms or be immediately lethal)**
3. **Homogeneity of substrate (Trying to decompose a single material.)**

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pH

- **Only a limited number of species prefer pH levels outside the range of 6.5 to 7.5.**
- **Other bacteria try to use stressor proteins to survive outside their ideal pH levels. In those situations where survival is possible, bacteria sacrifice cellular size and reproductive speed.**
- **pH can often be corrected by the addition of buffering materials, or by the addition of feedstocks with opposite pH characteristics of existing stocks.**

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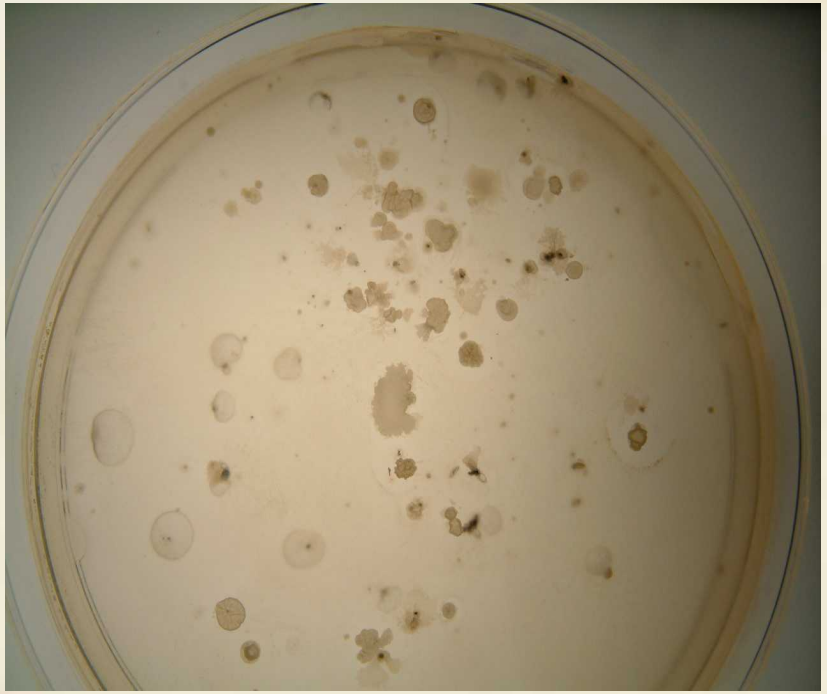
pH and Growth



5.5 **8.5**

36 hour incubation @ 52˚C

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pH and Growth

6.0 **8.0**

36 hour incubation @ 52 ° C

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pH and Growth - 7.0

36 hour incubation at 52º C

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pH and Growth – 7.0

36 hour incubation @ 52°C

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Toxins

- **Compounds such as antibiotics (Produced naturally by actinobacteria or residually present in manures from animals with diets high in antibiotics)**
- **Excessive levels of certain minerals**
- **Chlorines from treated water**

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Homogenous Feedstocks

- **Lack of Diversity in materials can result in lack of diversity in microbial populations.**
- **Attempting to compost bio-solids, wood, leaves, manure or any single material by itself, typically results in limited forms of soluble Carbon, and either too little or too much Nitrogen.**

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Homogenous Feedstocks

- **Problems may include long processing times (wood and leaves)**
- **Failure to achieve temperature (manures)**
- **Excessive temperature (wood, aerated bio-solids)**
- **Excessive and persistent odor (wood, manures, bio-solids)**

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Homogenous Feedstocks

- **Regularity in types and sizes of feedstock particles limits diversity by encouraging success of a few strains most suited to that particular feedstock.**
- **Diversity in types and sizes of feedstock particles encourages diversity of microbial populations.**

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Diversity

- **Diversity is essential because not all bacteria can digest the same substrates.**
- **Bacteria that are the most motile, aggressive, hardy, etc., typically get the easiest foods to digest (fewest number of reactions required to yield energy).**
- **Bacteria that are the least motile and hardy have had to learn to digest greater varieties because they seldom have the opportunity to digest the simpler substrates.**

We refer to the difference in bacterial digestive abilities as Specificity.

Due to this Specificity,

MICROBIAL DIVERSITY is the *most important factor* in both complete decomposition and ODOR CONTROL !

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CATALYTIC PROTEINS

- **BACTERIA GENERATE SPECIFIC PROTEINS WHICH ALLOW THEM TO REACT WITH SPECIFIC CHEMICAL COMPOUNDS. THESE PROTEINS ARE CALLED - *ENZYMES*.**
- **WITHOUT THE CORRECT ENZYME(S) FOR A GIVEN COMPOUND, THE BACTERIUM CANNOT DEGRADE THAT COMPOUND .**

Because each bacterium must generate enzymes to react with every compound it degrades, each strain of bacteria can generally only digest a limited number of compounds of the many thousands that are generated in organic waste decomposition !

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Many thousands of different compounds require hundreds – even thousands of different types of bacteria !!

Diversity !

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Consequently,
Microbial Diversity
is Critical
to Odor Control
And to Decomposition!!

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How do we Encourage Diversity and Control Odor?

- **Pay more attention to feedstock assembly and combinations.**
- **Spend more time creating the windrow or pile with good mixing, structure, and moisture.**
- **Only disturb the populations when necessary.**

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When is Turning "Necessary"?

- **The windrow does not achieve sufficient temperature initially.**
- **The windrow temperatures begin to decline substantially and consistently.**
- **The windrow is too dry and water needs to be added.**
- **The windrow is too wet and water needs to be released.**

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Effects of Unnecessary Turning

- **It is the equivalent of fanning a fire, inciting combustion.**
- **It damages microbial cell tissue and interrupts decomposition.**
- **It assists in volatilization of undigested, odorous compounds.**
- **It wastes essential soluble carbon into the atmosphere.**
- **It wastes fuel and money and contributes to the greenhouse gas problem.**

Good Composting Requires

Creating the best possible environment for the growth of microbial communities,

Then,

<u>ALLOWING</u> THOSE COMMUNITIES TO GROW !

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So, *Does it have to smell?*

It may never be possible
to eliminate
100% of odor
occurrences
in composting.

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So, *Does it have to smell?*

By promoting the proper conditions

And managing those conditions based on microbiology – not mechanics,

the vast majority of offensive odors can be eliminated or contained.

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Controlling Odor Requires

Creating the best possible environment for the growth of diverse microbial communities,

Then,

<u>ALLOWING</u> THOSE COMMUNITIES TO GROW !

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