Microorganisms' Growth©

TWC Enterprises

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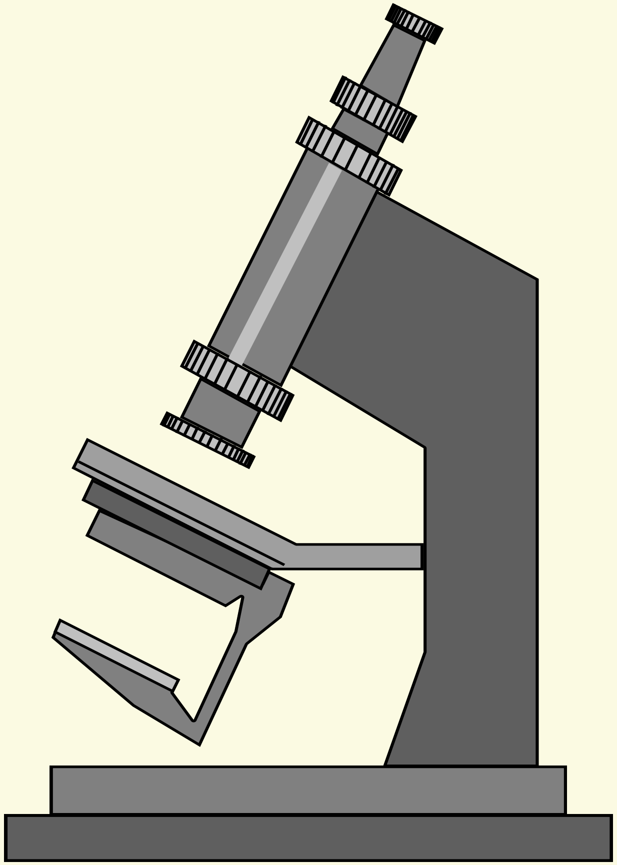
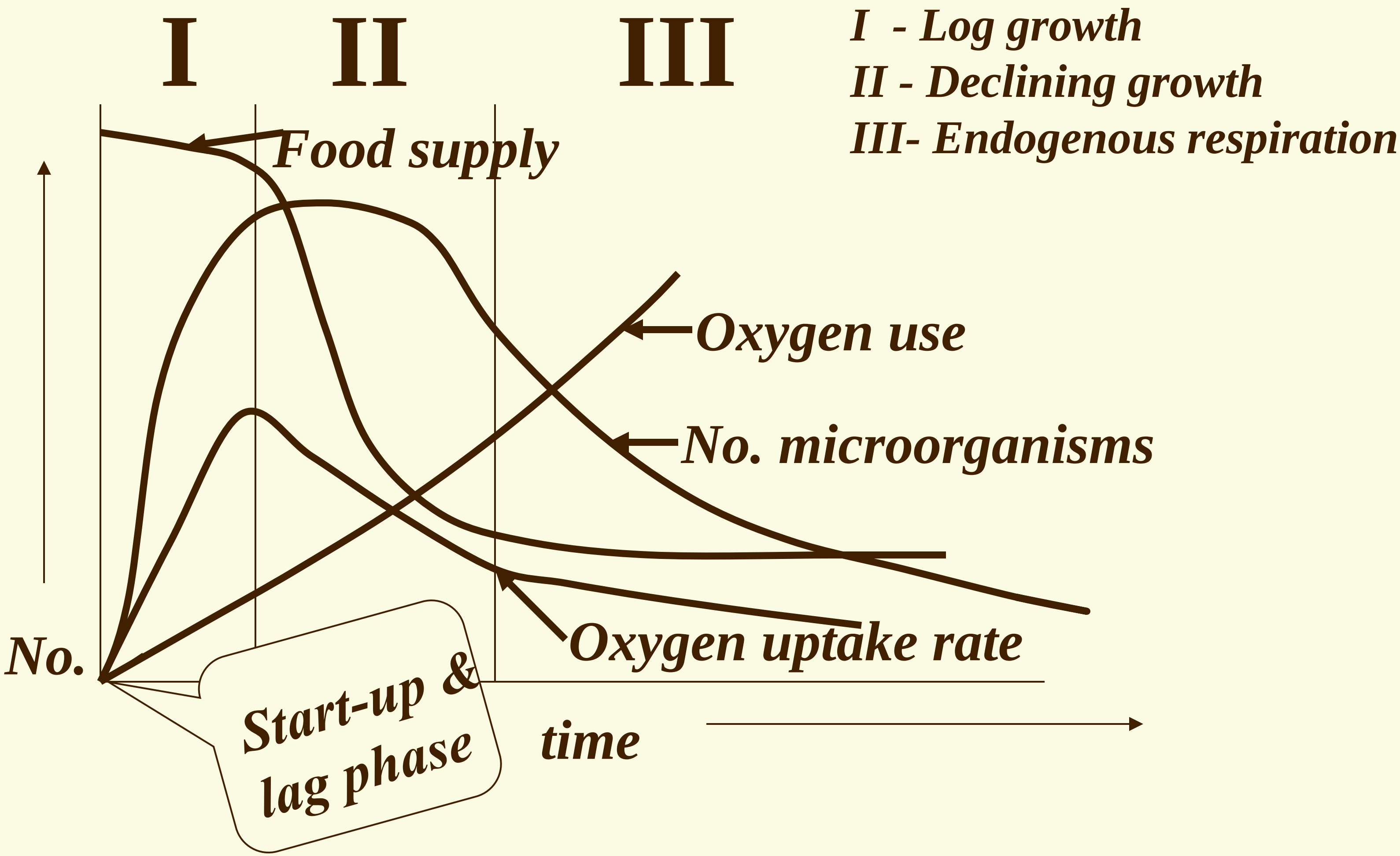


Growth Phases Curve



Oxidation in the aeration tank by aerobic bacteria under aerobic conditions

Heterotrophic bac-T eat carbon

$$C + O_2 \xleftrightarrow[\text{bac-T}]{} CO_2$$

These bacteria are hearty and fast growing. They begin to grow immediately after start-up in summer.

Autotrophic bac-T eat ammonia with DO.

$$NH_3 \xleftrightarrow[\text{bac-T}]{} NO_2^{-1} \xleftrightarrow[\text{bac-T}]{} NO_3^{-1}$$

These bacteria are sensitive and slow growing. They don't start to grow until about 6 + days later. It takes 4 parts O_2 to react with 1 part NH_3-N.

Reduction in the aeration tank by aerobic microorganisms under anoxic conditions

- Anoxic conditions means that there is no DO! The aerobes then seek the next easiest source of oxygen: the oxygen attached to the NO_3^{-1} (nitrate), reducing it to N_2 and O_2. This is called denitrification; it is desirable in the aeration tank as the oxygen released is once again available for use in reacting with carbon and ammonia.
- If there isn't an anoxic zone in the aeration tank denitrification may occur in the secondary clarifier, thus degrading effluent quality and wasting energy through loss of available DO.

Log-growth Protozoa- Phase I

- During start-up and the lag phase, Amoebae usually predominate
- Testaceous (shelled) amoebae grow when NH_3-N < 1.0 mg./L.
- During the log-growth phase, Flagella typically predominate

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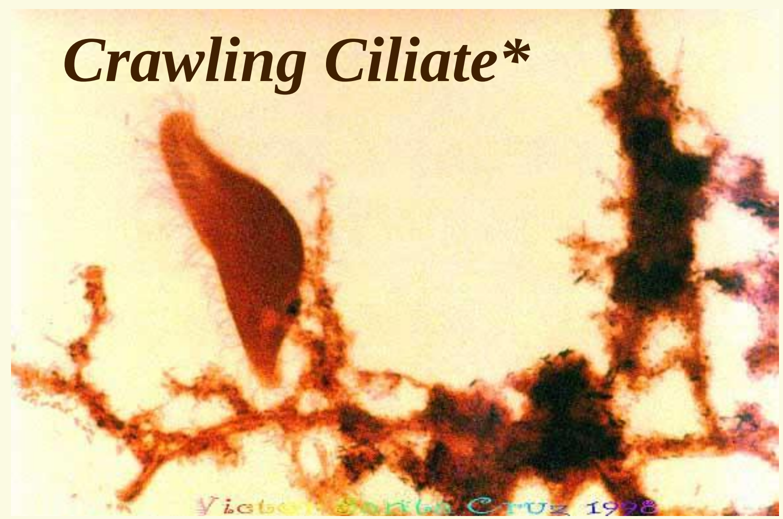
Declining growth Protozoa- Phase II

- During declining-growth, ciliates predominate
- Best performance usually occurs at this time with lots of ciliates, esp. stalked ciliates



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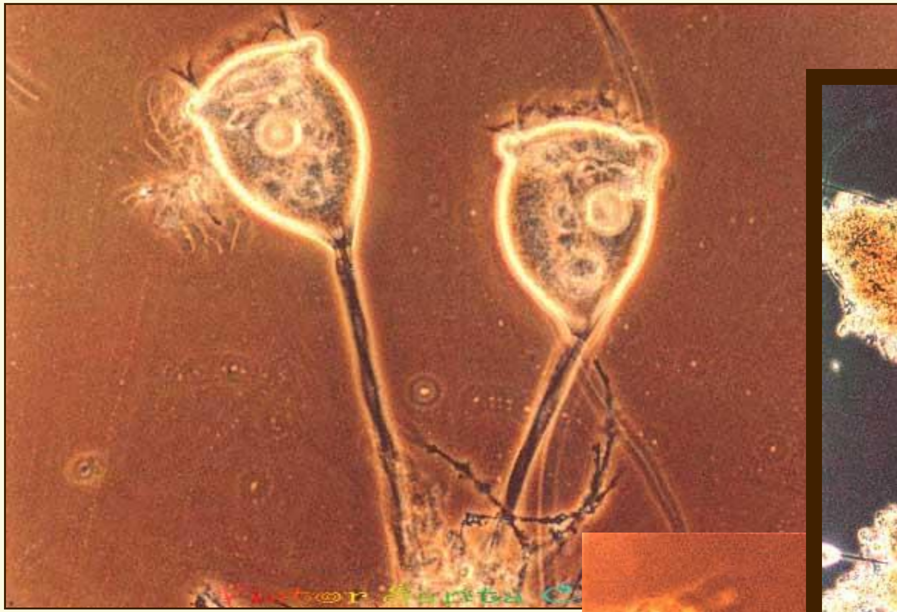
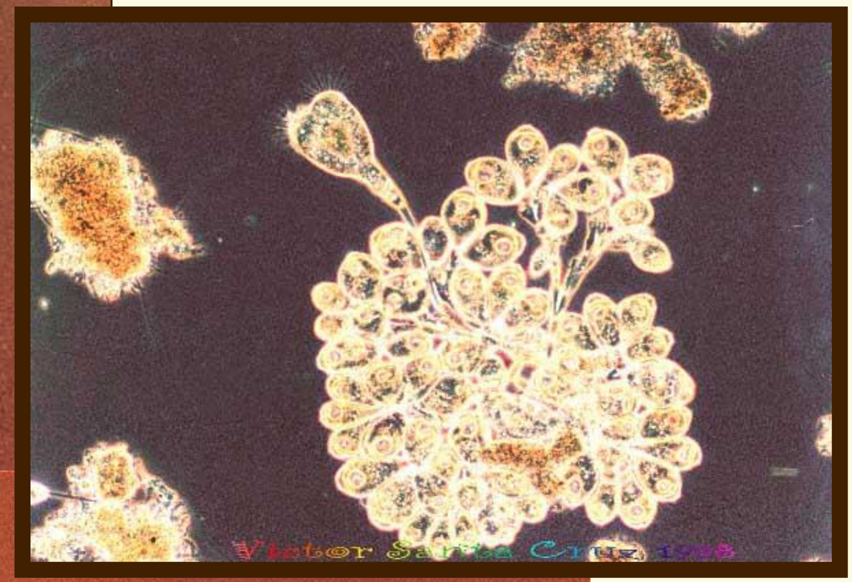
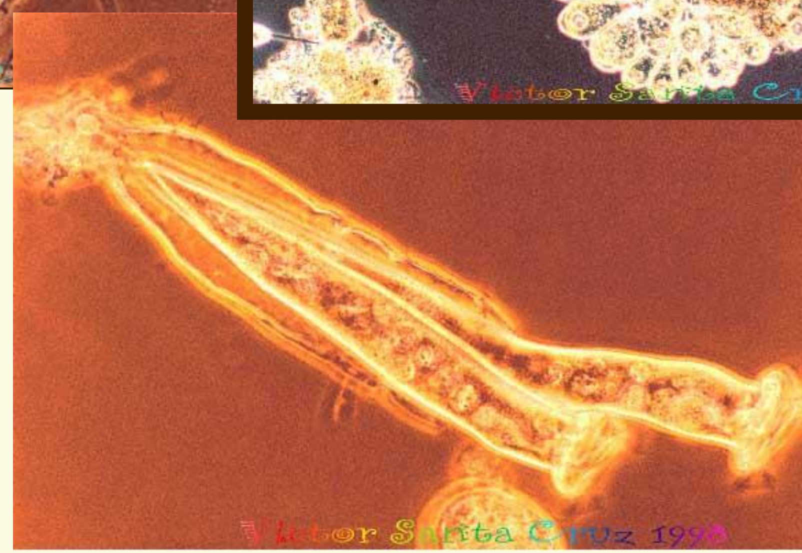
Stalked Ciliates







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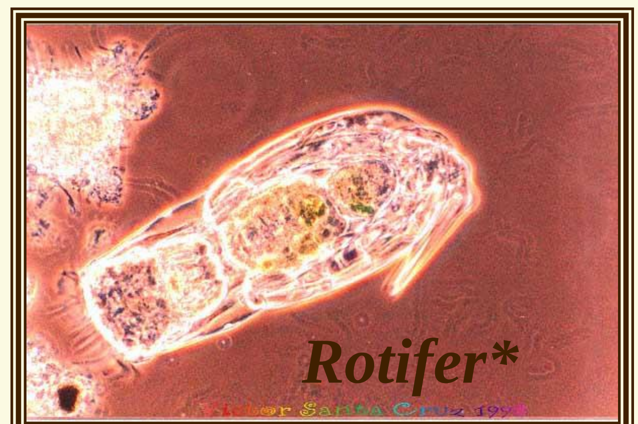
Endogenous Respiration- Phase III

- Higher life forms such as Metazoa, i.e. Rotifers, worms, etc. have had time (higher sludge age) to develop
- It is very common to see a lot of diversity
- This “death” phase results in floc break-up and dispersed floc

Diversity & Dispersed Floc*



Rotifer*

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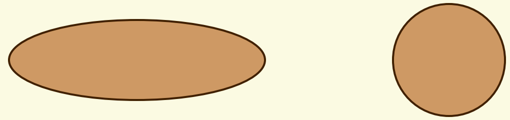
What do bacteria look like?

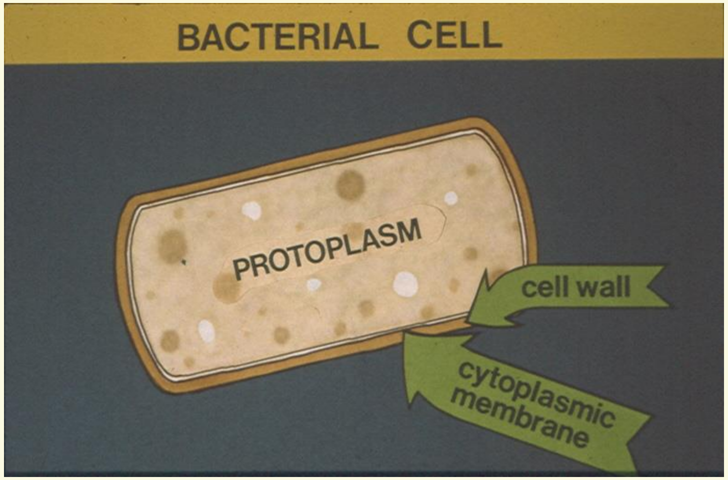
- They come in all different sizes and shapes, but the two most common seen in activated sludge are *bacillus* (rod shaped) and *cocci* (ball shaped)

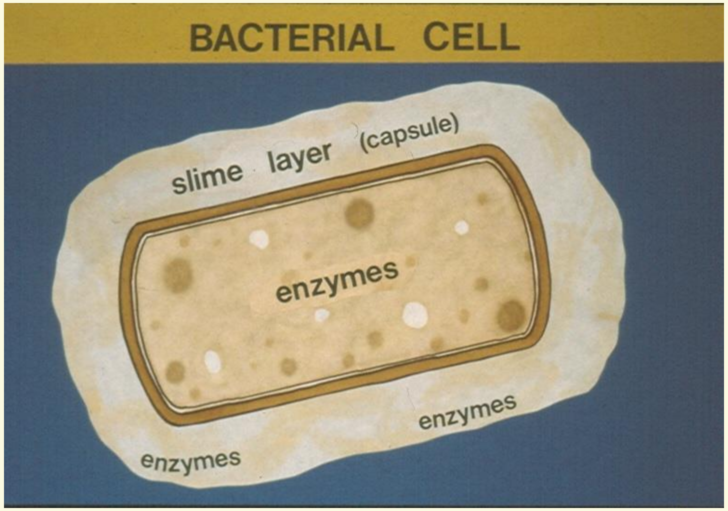


- The bacteria are the microorganisms that feed on the BOD in the wastewater
- Protozoa, Metazoa, etc. are higher life forms that feed on the lower life forms in the food chain

What's a bug look like?

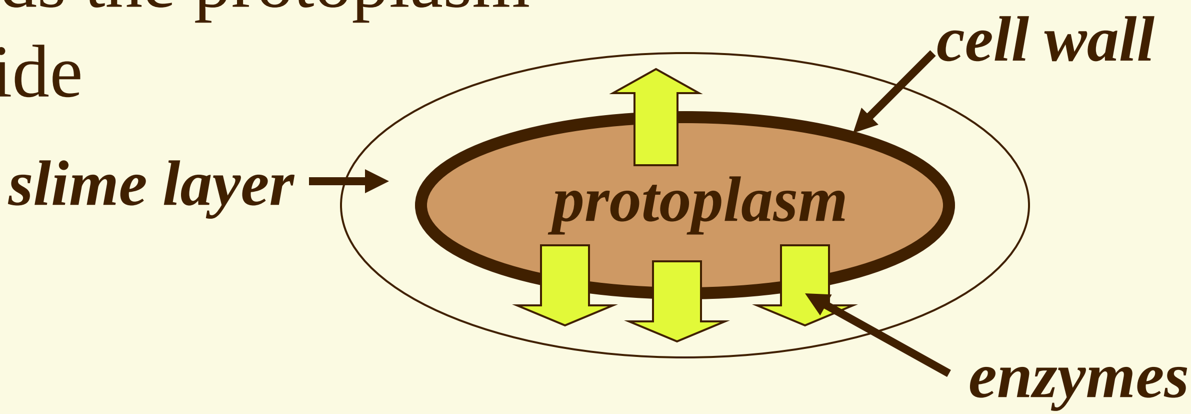
- The bacterial cell has a cell wall that imparts rigidity and a membrane that hold the protoplasm inside
- Different bacteria secrete different enzymes into the slime layer (bug glue)





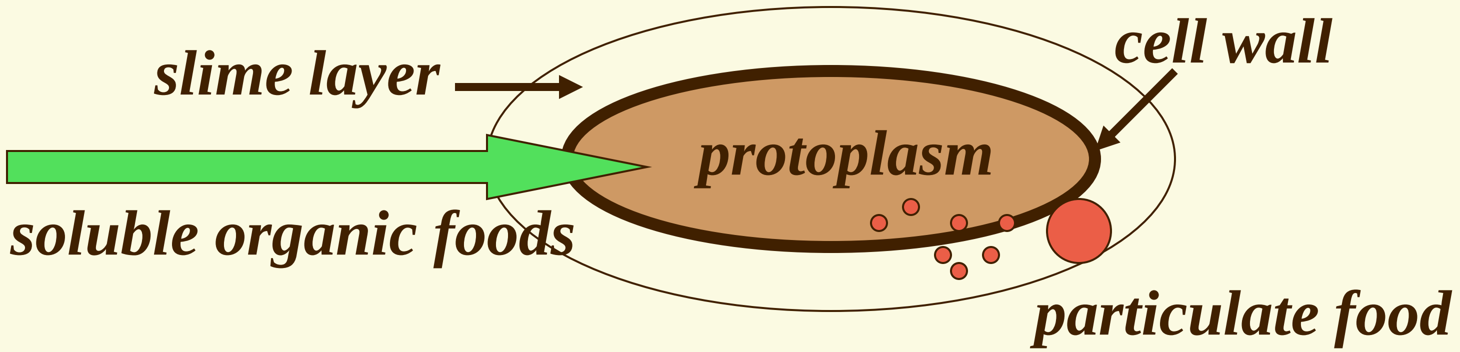
What's a bug look like?

- A bacteria cell has a cell wall with a cytoplasmic membrane that imparts rigidity and holds the protoplasm inside
- Different bacteria secrete different enzymes into the slime layer (bug glue)



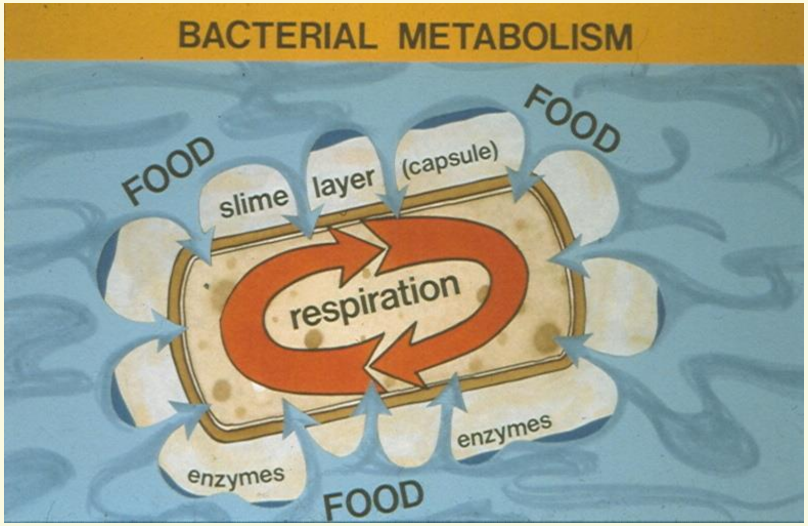
How do they eat?

- Soluble organic foods e.g. sugars, alcohols, acids, etc. can rapidly pass through the membrane into the cell for food for synthesis
- Particulate food must be first broken down by the enzymes into small enough size to pass through the pores of the membrane



How do they eat?

- Soluble organic foods, e.g sugars, alcohols, acids, etc., can pass through membrane into the cell for respiration for energy
- Soluble foods can be synthesized very rapidly.
- Solids must be broken down into small enough size to pass

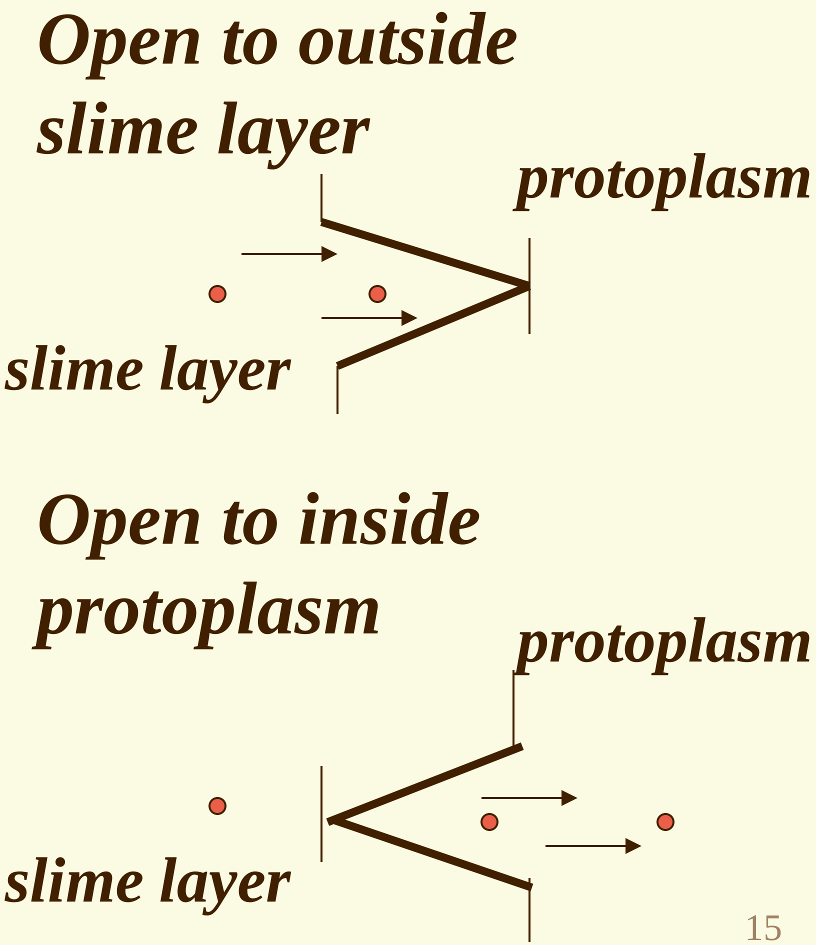


What causes the slime layer?

- Waste by-products!
- When food is stored in the cell during the declining growth phase, waste products are generated within the cell.
- These waste by-products are excreted onto the outside of the bug, forming the layer
- The slime layer is simply natural polysaccharide polymers (bug glue), that permits adsorption of particulate matter

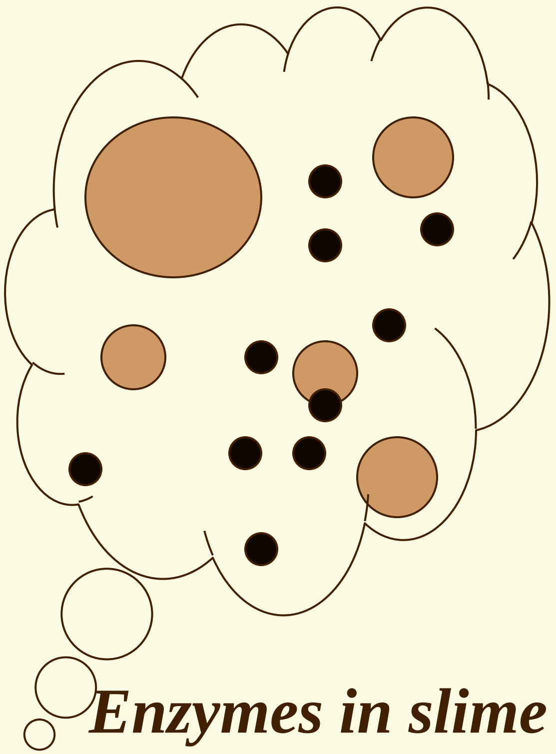
How does the food pass through?

- The cell wall has pores with “gates” that open and close, allowing the food to enter the pore from the outside and then pass into the cell
- The gate are similar to “locks” on our river systems for watercraft



How is the food broken down?

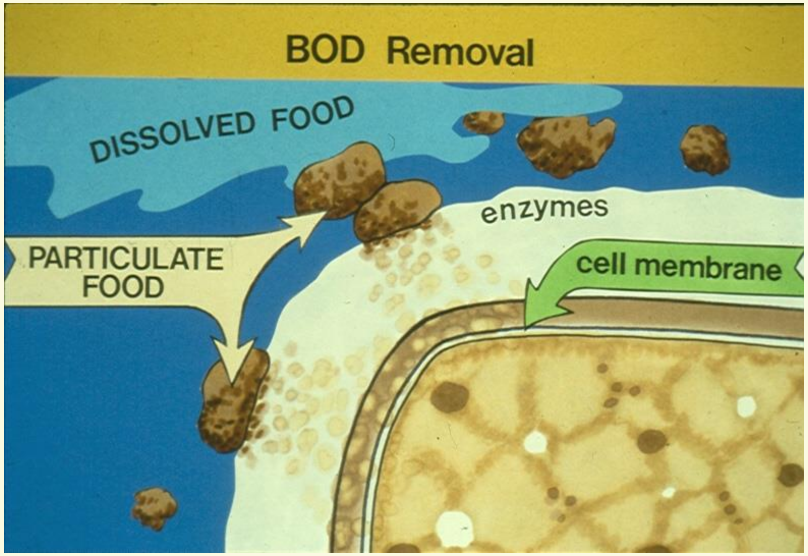
- By the enzymes!
- Large particles are simply broken into smaller (sufficiently small to pass through the gates, e.g. the dark ones illustrated) particles by enzymes that are secreted into the slime layer



Enzymes in slime layer break down larger particles

How is solid food broken down?

- By the ***enzymes*** in the slime layer
- The slime layer is simply natural polymers that are secreted as waste by-products from inside the cell

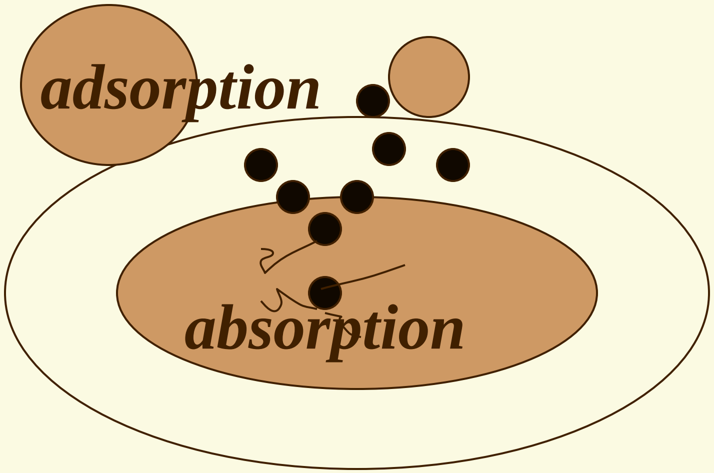


How do bugs obtain solid food?

Through ***adsorption***

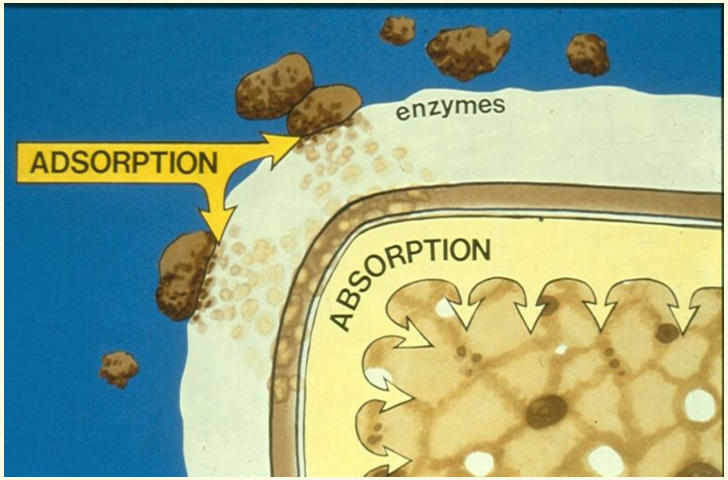
- The sticky 'bug glue" or slime layer causes the particulate food to stick to the cell where it is then broken down by enzymes
- The bug glue also causes other particles to stick or ***flocculate***

Absorption, or synthesis, of the food then occurs after the food pass into the cell



How do bugs obtain solid food?

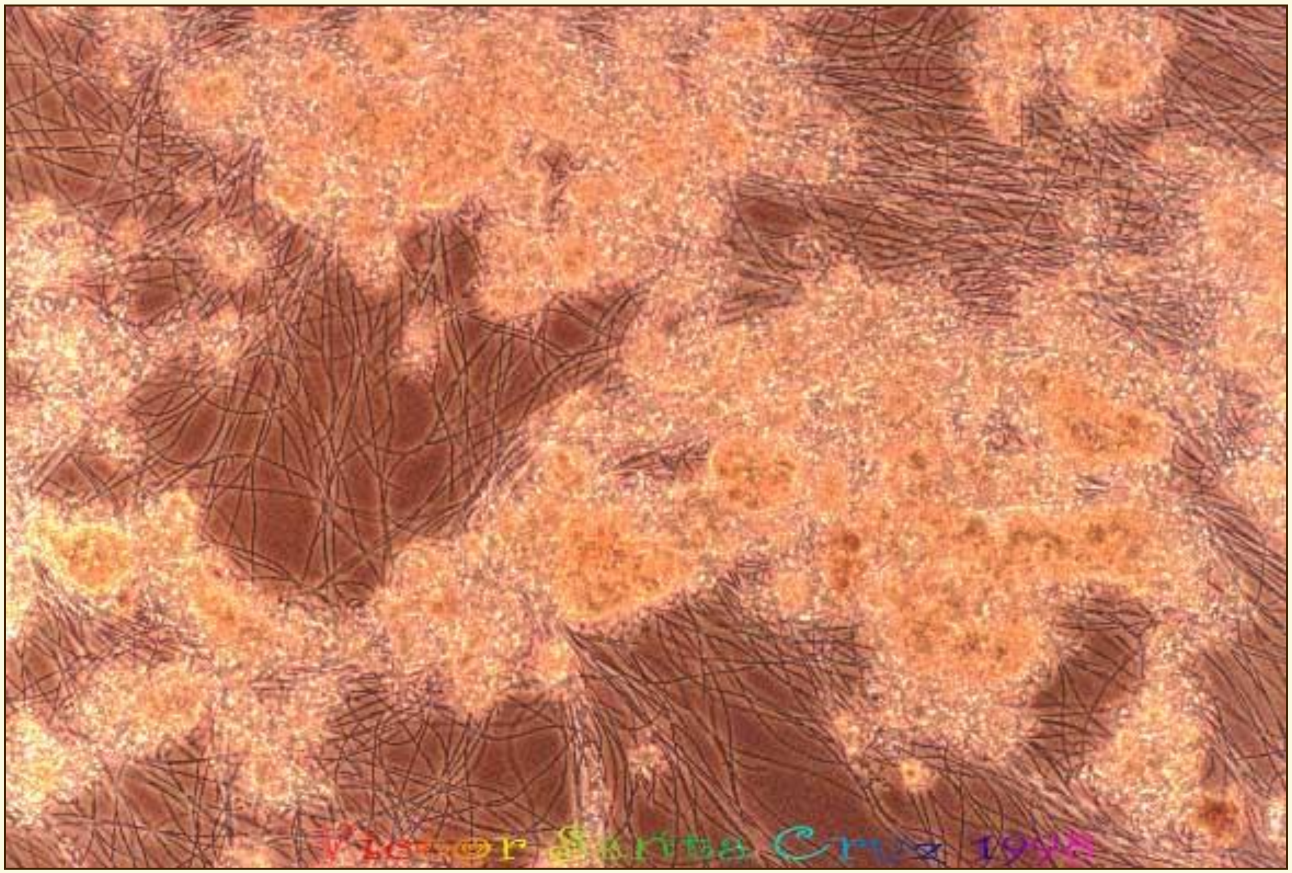
- Through ***a<u>d</u>sorption***. The sticky "bug glue" or slime layer cause the particulate food to stick to the cell where it is then broken down by the enzymes.
- The "bug glue" also causes other particles to stick or ***flocculate***
- ***A<u>b</u>sorption***, or synthesis, of the food then occurs after the food passes into the cell.



Filamentous Bacteria

- Filaments can be ***good*** when they are not abundant. They form a "vertebrae" on which the floc formers can attach and grow.
- Filaments can be ***bad*** when they cause *interfloc bridging*. The filaments bridge from one floc particle to another, keeping them apart, preventing compression and subsequent thickening of the sludge.

Filament 021N*:
The Mother of all filaments!



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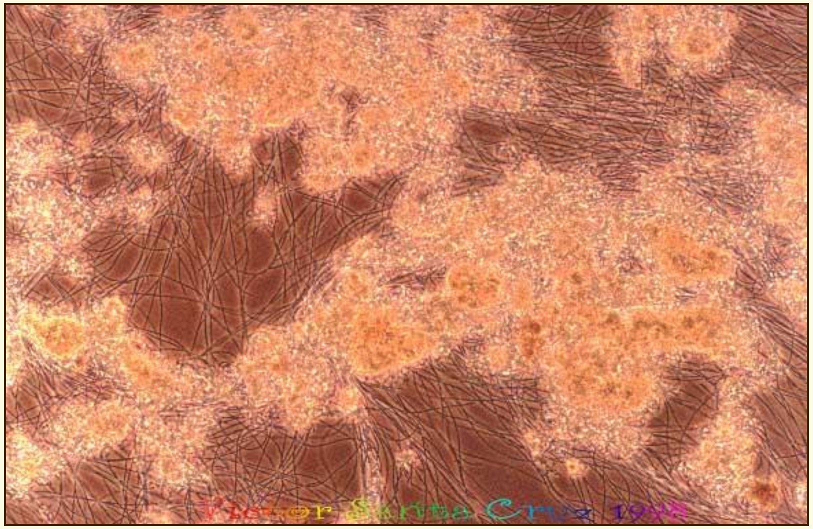
021N – Mother of all filaments

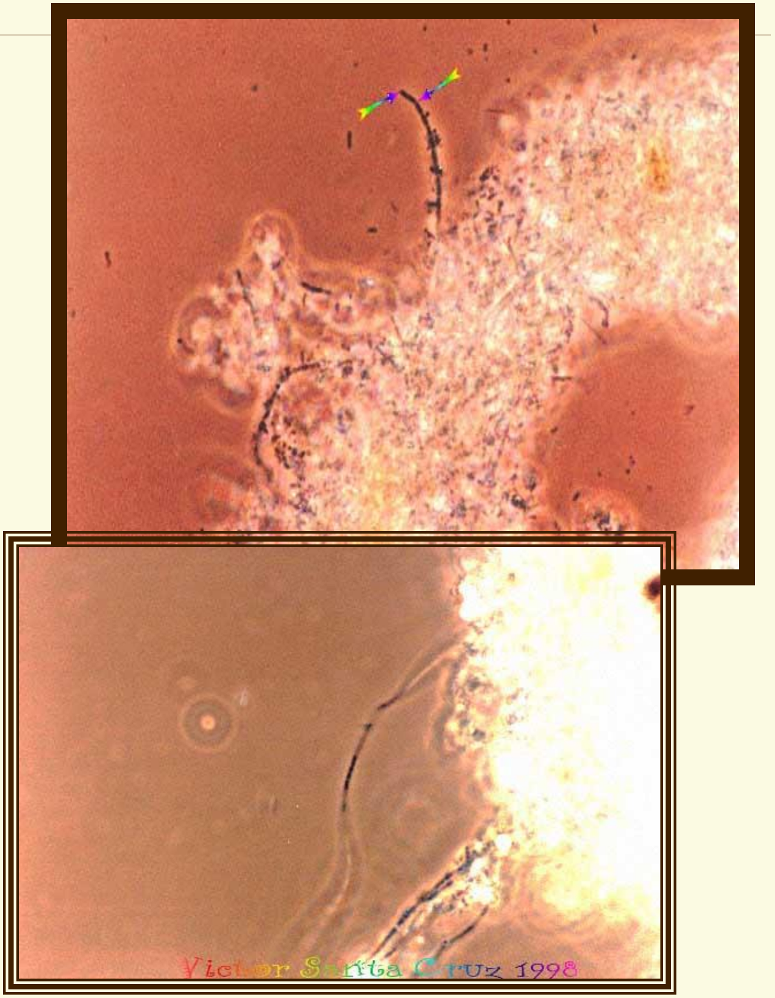


Note extensive interfloc bridging

Slime City: Mixed liquor at PPI

Filament 1701*, the most common

- Note in the pictures that there is not much interfloc bridging
- This filament is now beneficial since it provides a site for floc-forming bacteria to attach, e.g. a vertebrae



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Nocardia*, with true branching

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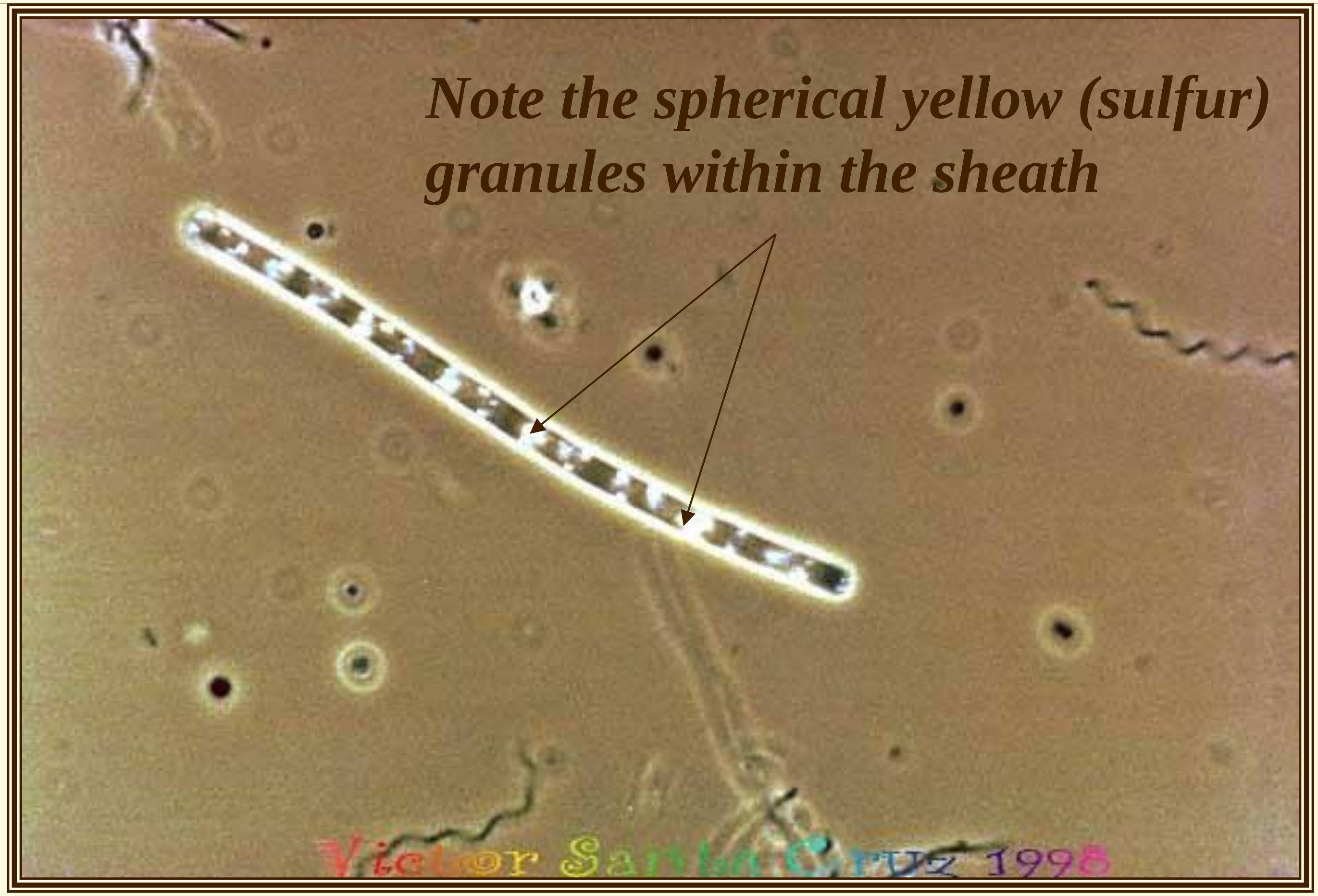
Beggiatoa at 1000X



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N. limicola II* at 1000X

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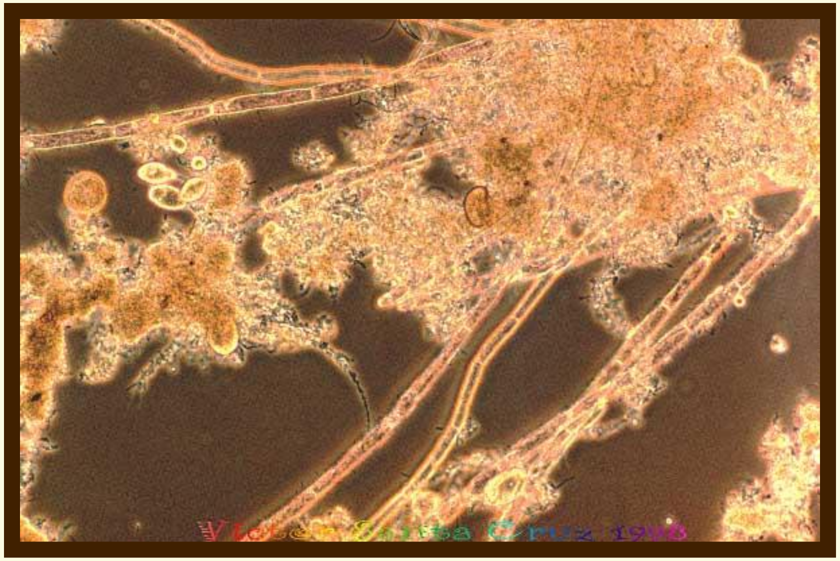
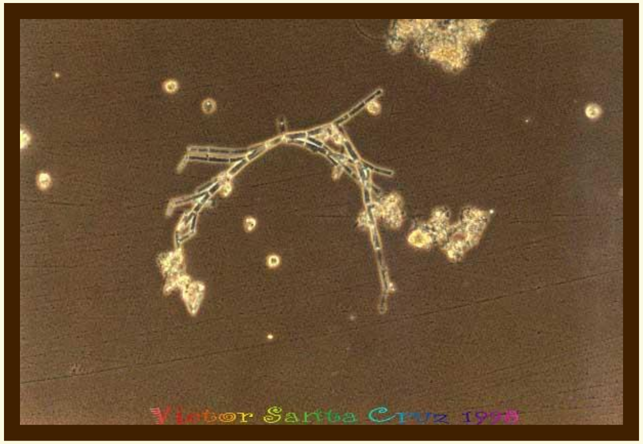
Fungi* at 100X

- They look like filaments but they're not
- Their presence in large quantities indicates a pH problem, i.e. acidic conditions





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Filaments: Interfloc Bridging

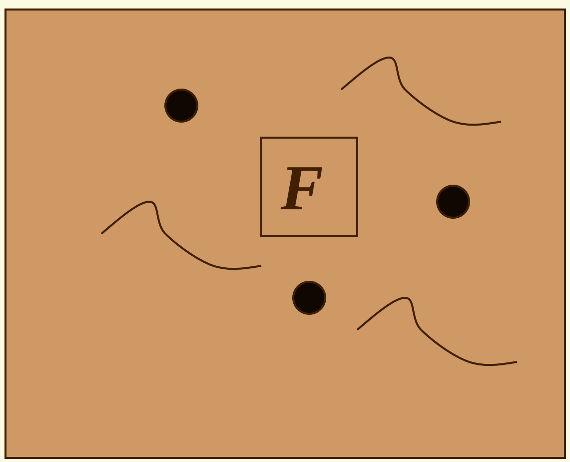
- Results in a low-density sludge that will settle poorly. The sludge will not thicken and compact.
- Results in high sludge blankets that are difficult to control.

Filaments: How they eat

- Favorite Foods: soluble, short chain organic acids, e.g. acetic, propionic, etc.
- In a low F/M environment, e.g. diluted MLSS, they can get to the food more readily than can the floc forming bacteria
- Biological *selectors* are used to create favorable conditions, i.e. high F/M for the floc formers to compete for the food

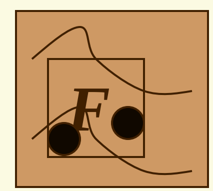
Biological selector

Large tank: floc formers can't compete readily



Low F/M

High F/M



Small tank: floc formers can better compete for food

PORTION PAC PRETREATMENT FACILITY

Principal Project Individuals

Sam Harris & Bob Lindhorst

Lynn Marshall

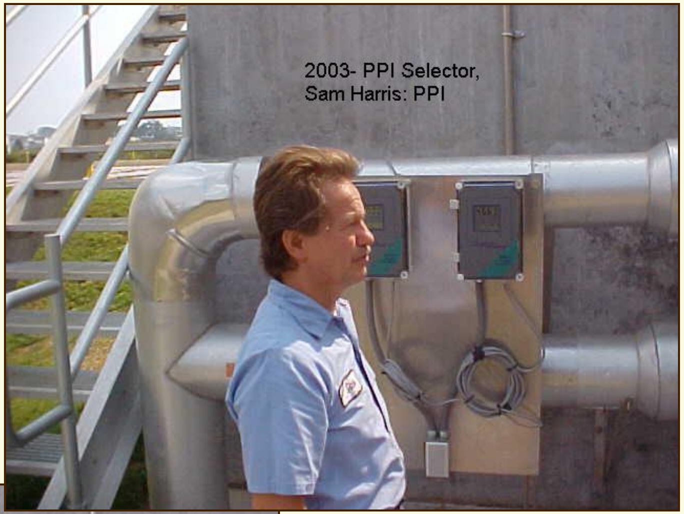
Matt Walbridge

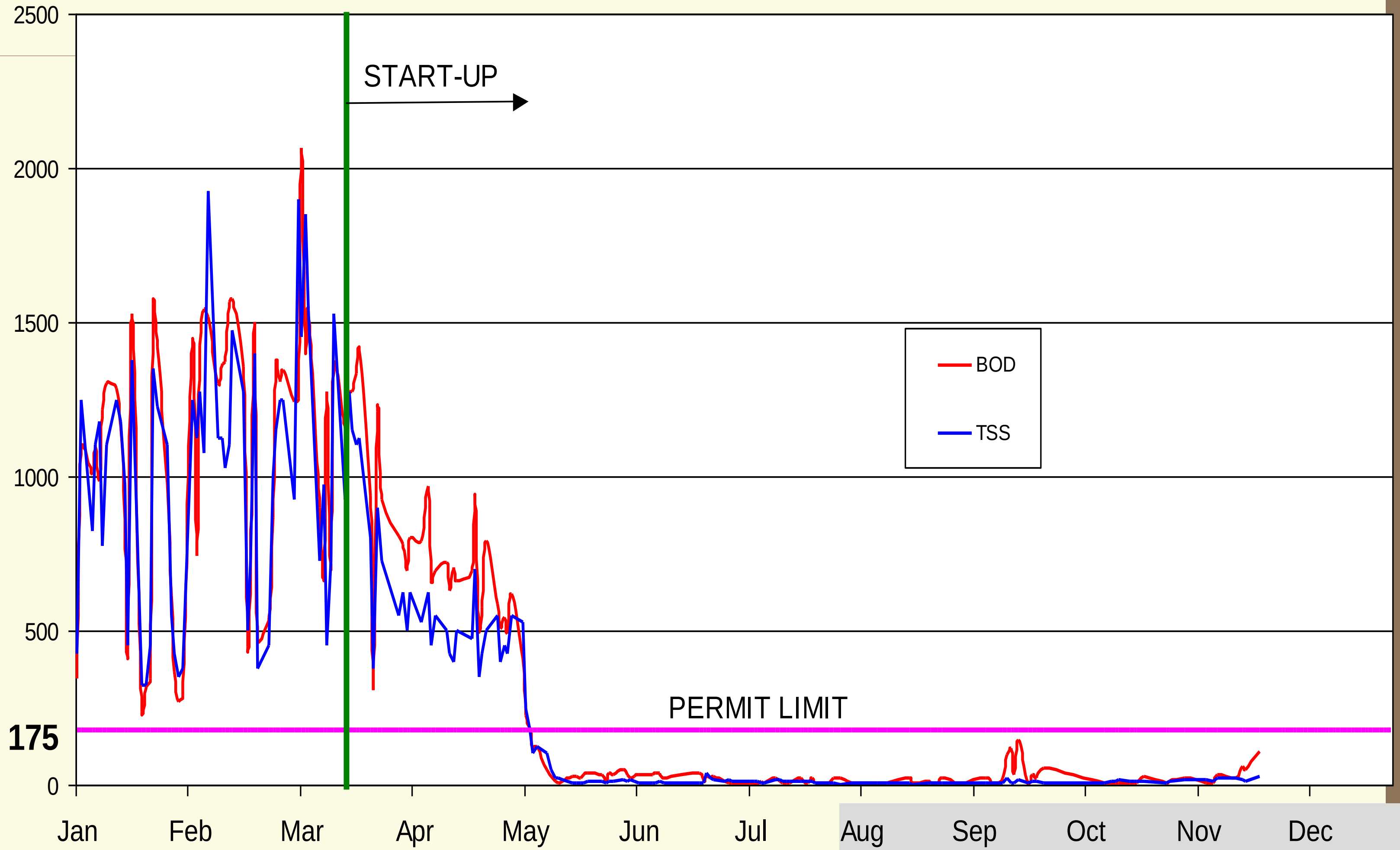
Bob Beyer

Brad Miller

Mark Rogge & Sam Swanson

Biological selector w/ 2 chambers





2003 BOD AND TSS EFFLUENT CONCENTRATION (mg/l)

I. Log Growth Phase

- Settling- Slow (SSV_5 > 750 cc/L)
- Floc- Low density & dispersed
- Microorganisms- Flagella
- Rate of growth- Logarithmic
- OUR- High, possibly insufficient air supply, typically > 20 mg O_2/hr/gm MLVSS
- DO- Low (due to high OUR)

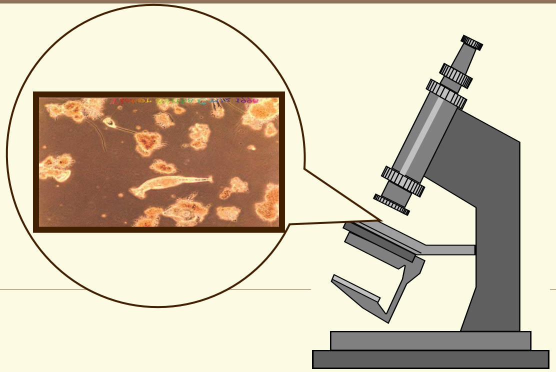
II. Declining Growth Phase

- Settling- Normal (SSV5 = 600-750 cc/L)
- Floc- Agglomerates (due to “bug glue”)
- Microorganisms- Ciliates
- Rate of growth- Declining
- OUR- Acceptable, 12-20 mg/hr/gm MLVSS
- DO- Acceptable (and controllable!)

III. Endogenous Phase

- Settling- Fast (SSV5<600cc/L) but could be slowed as MLSS increases
- Floc- Dispersed (due to cell death)
- Microorganisms- Metazoans
- Rate of growth- “Ethiopian” or “Somalian”
- OUR- Low, stable, e.g. < 12 mg/hr/gm
- DO- High if MLSS is low, but can be low if MLSS is high

Summary



You can see anything under the microscope

- *Predominance*: It’s what you see the most of that indicates process status
- *Diversity*: Just like we don’t all look alike, neither should all the bugs
- *Motility*: The bugs should be moving around actively, not sluggishly, indicating a healthy population;