

A microscopic view of numerous blue, rod-shaped bacteria, likely probiotics, against a light blue background. The bacteria are of various sizes and orientations, some appearing to have small protrusions or flagella.

# The Gut Bug Connection

By Greg Paul

# Applied Microbiology

- Personal Experiences relative to microbiology
- Use of Microbiology in wastewater treatment plant (WWTP)
  - Bug counts/troubleshooting
  - Tracking/Charting operational variables

# Applied Microbiology

- WWTP microbiology experience lead to starting unique business
- Mentoring operators
  - Optimizing methods to grow specific microbes
  - To improve wastewater treatment performance - EBPR

# WHAT CONNECTS WWTP & GUT?

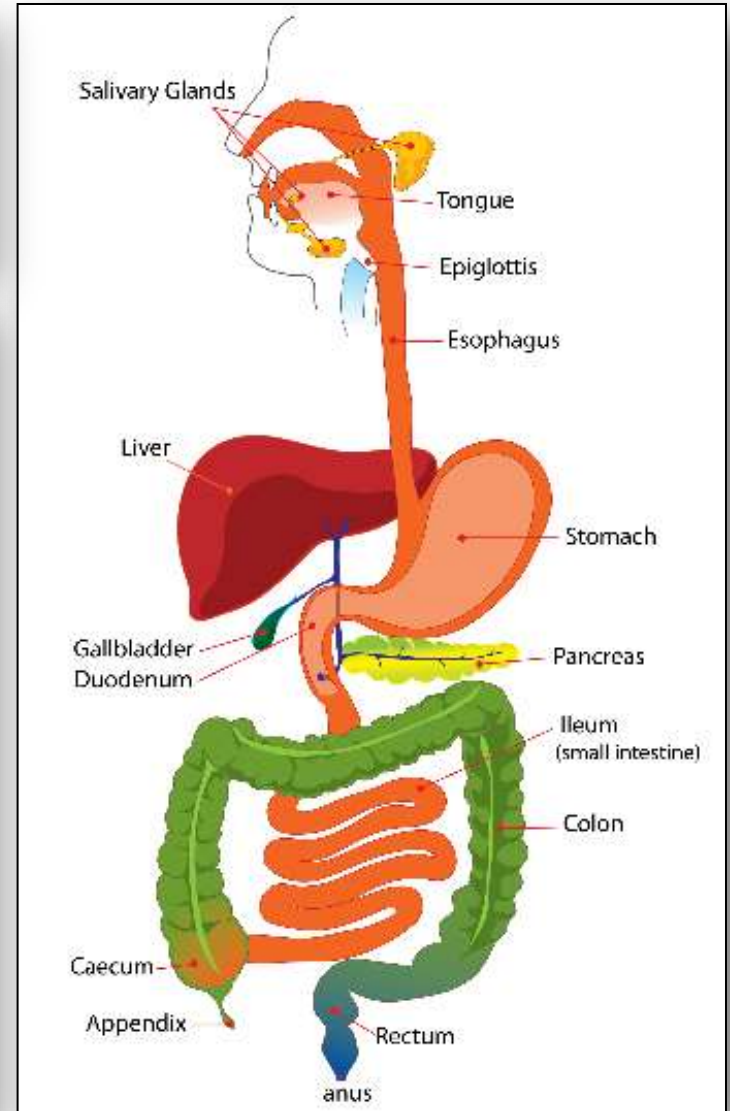
## MICROBES.....

- Pass through long tubes
- Colonize each environment
- Overlap in species
- Perform valuable work
- Need to be managed to produce desired results

**RECENT DISCOVERIES  
IN PHYSICAL &  
MENTAL HEALTH  
Related to the Gut  
Microbes**

**DNA Sequencing Made it possible**

# Let's Take a Tour





# Actually Starts with the Toilet

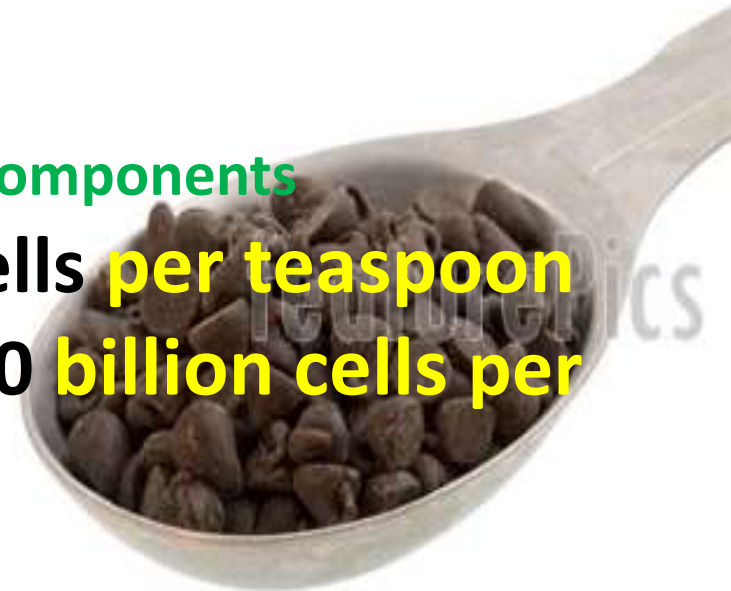
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**This is where humans donate  
their excess Microbes to the  
Wastewater Plant**

***Stool - 60% by weight - Microbes***

# Background on the Donated Human Microbes

- Gut is home to **100 trillion** bacteria
- Avg. US adult ~**1,200 different** species
- **STOMACH** –
  - not many microbes - too harsh
  - Acid bath & enzyme
  - Breaks down food into digestible components
- **SMALL INTESTINE** – 50 million cells **per teaspoon**
- **LARGE INTESTINE (COLON)** – 500 **billion cells per teaspoon**
- Your microbiome can weigh **5 lbs.**
- 1 gram fecal material – more microbes than earths' human population





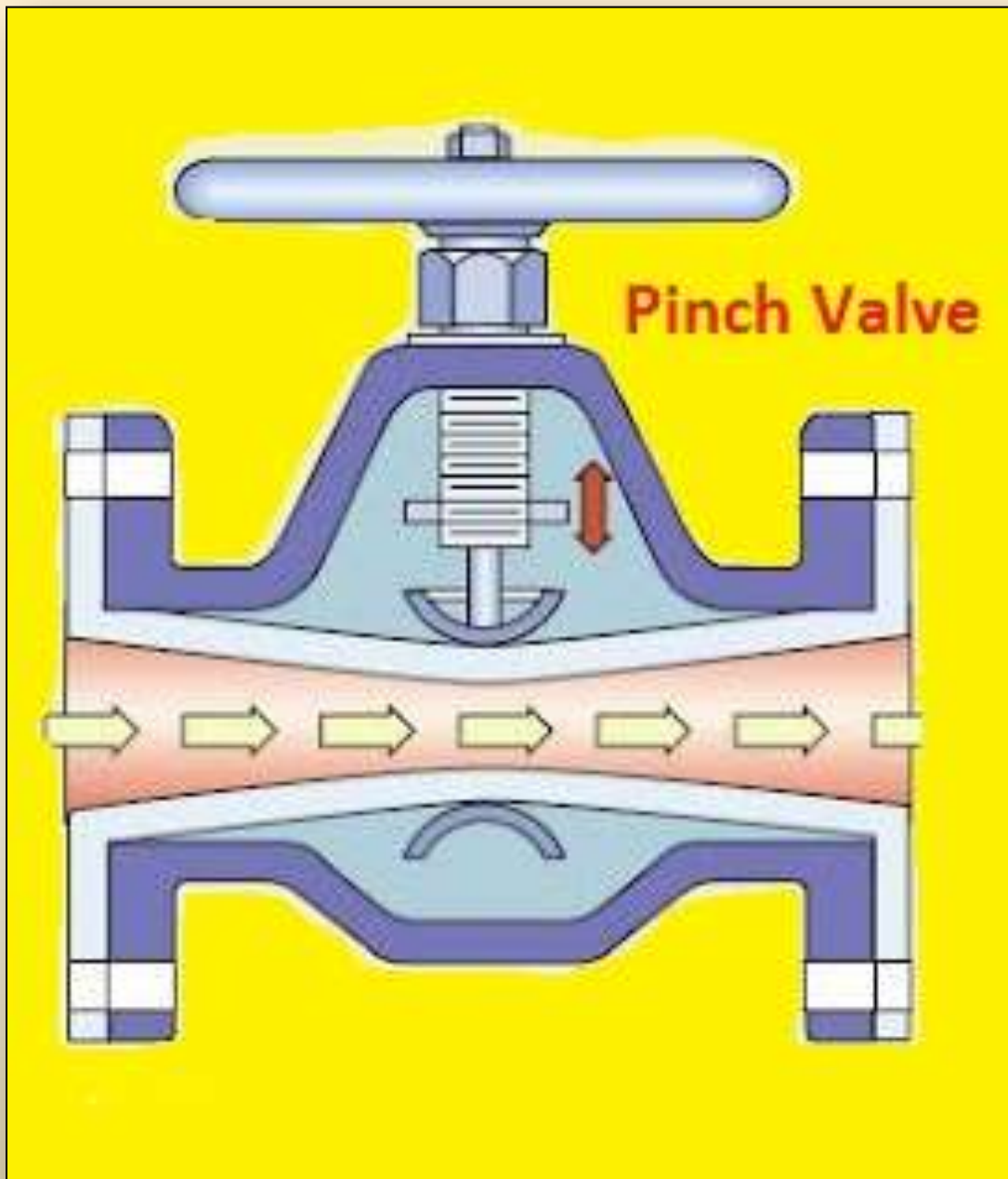
# Background on the Donated Human Microbes

- BACTERIA are tiny factories
- Microbes in our gut;
  - **Ferment** indigestible foodstuffs for us
  - Supply **energy**
  - Manufactures **vitamins**
  - Breaks down **toxins** and **medications**
  - **TRAINS IMMUNE SYSTEM** -----
- Manufacture - acids, gases, fats & Harmful bacteria cause diarrhea
- 100-150 times more microbial genes (2.3M to 3.4M) compared to the 23,000 human genes



**It Can Be Exhausting  
Depositing Your Microbes**

*Side  
Note*

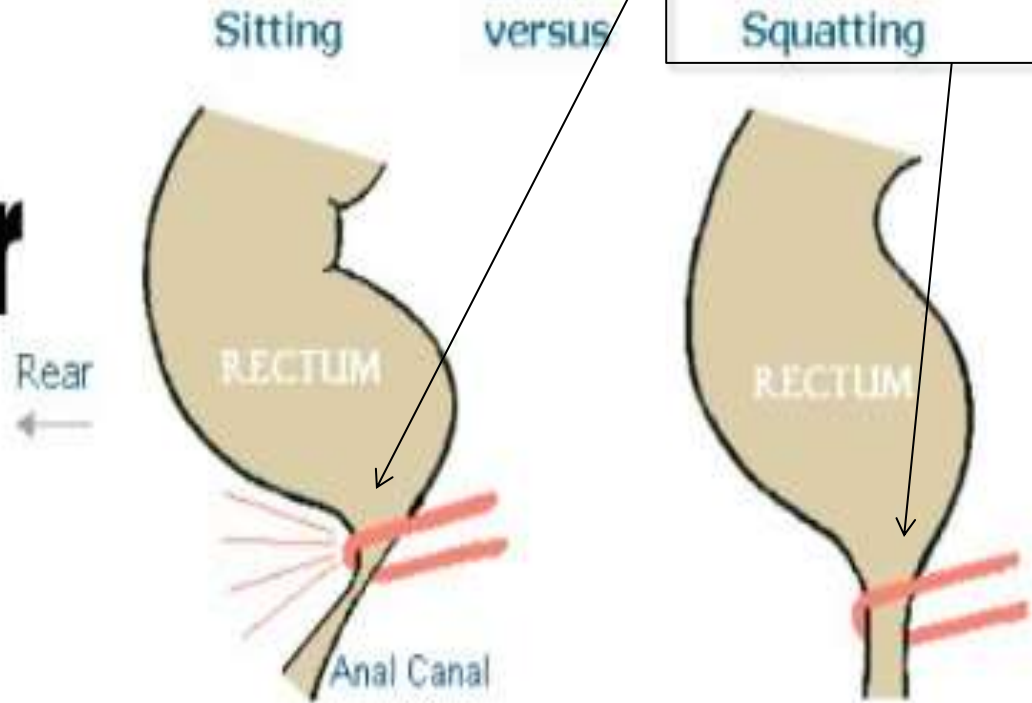


# Pinch Valve and Pooping

# What is the Proper Way to Poop?

# What is the Proper Way to Poop?

**Our Human Pinch Valve**  
When we sit it closed  
When we squat it opens



To maintain continence the puborectalis muscle "chokes" the rectum

Squatting relaxes the puborectalis muscle and straightens the rectum

**pew-bow-rec-tail-us**

# Fixing the Collapsed Pipe or *opening the semi-closed valve* in Humans



**Why it Matters...**  
Sitting Position may causes undue Straining;  
**Diverticulitis**  
**Hemorrhoids**

PHySiCaL COMPARISON:  
SeWer/WWTP to  
HUMAN DiGeStive SyStEM

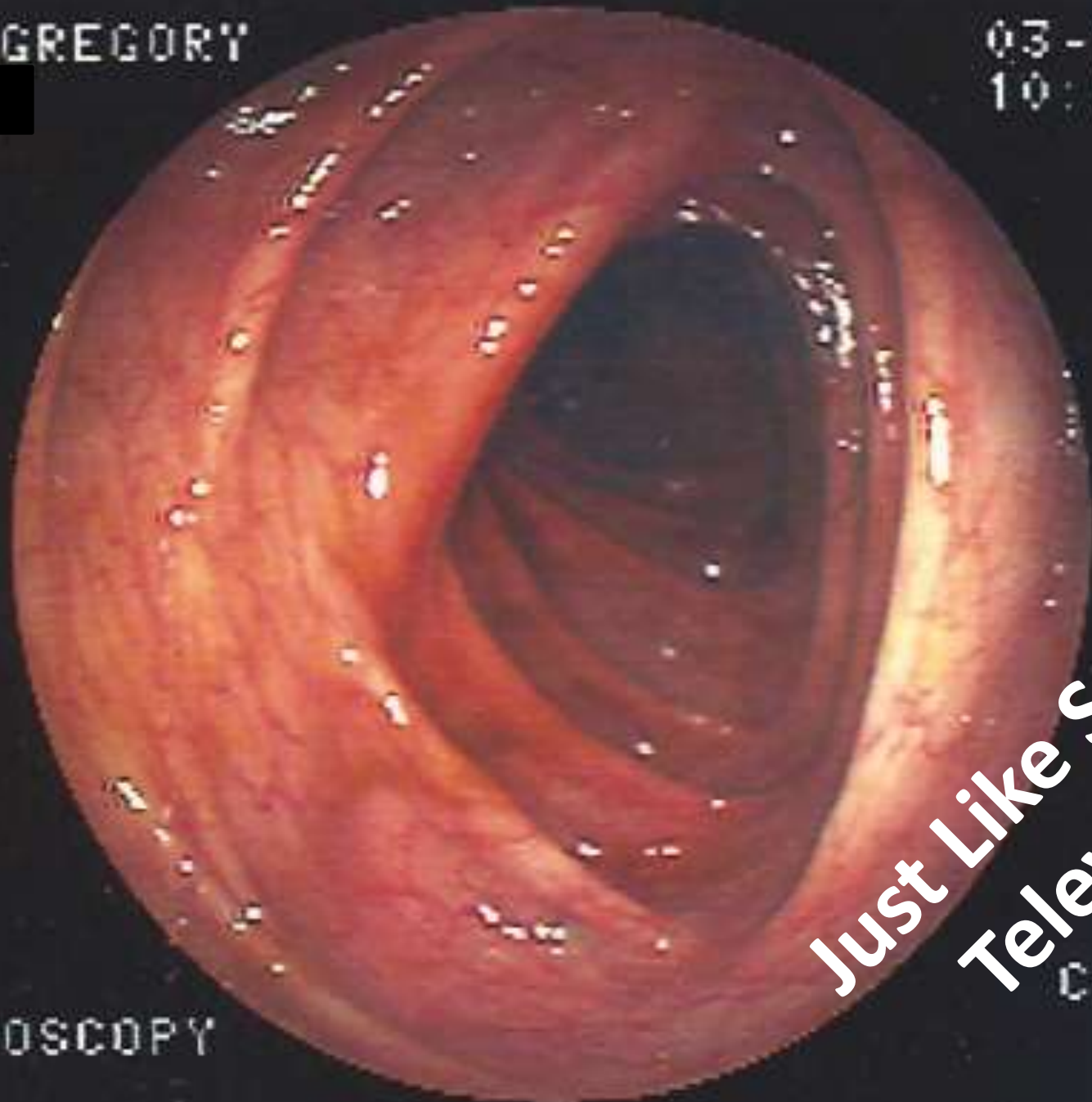
SEWER	Human
<p><b>Sanitary Sewer System</b></p>	<p>One Pipe - Various Jobs</p> <p><b>Esophagus</b> - transporting food/liquid to Stomach</p> <p>Stomach - Prep food for digestion</p> <p><b>Small Intestine</b> - Absorb nutrients</p> <p><b>Colon</b> - Dewater waste, produce fermented products recycle water/electrolytes</p> <p><b>Total of 25 to 30 Feet Long</b></p> <p><b>HRT - 9 hours (or less) to 3.5 Days +</b></p>

**BOTH - OUT OF SIGHT OUT OF MIND**  
**CMOM** WAS INVENTED TO DEAL WITH THIS COMMON PROBLEM

PAUL GREGORY

03-11-92

10:11:04



Just Like Sewer  
Televising

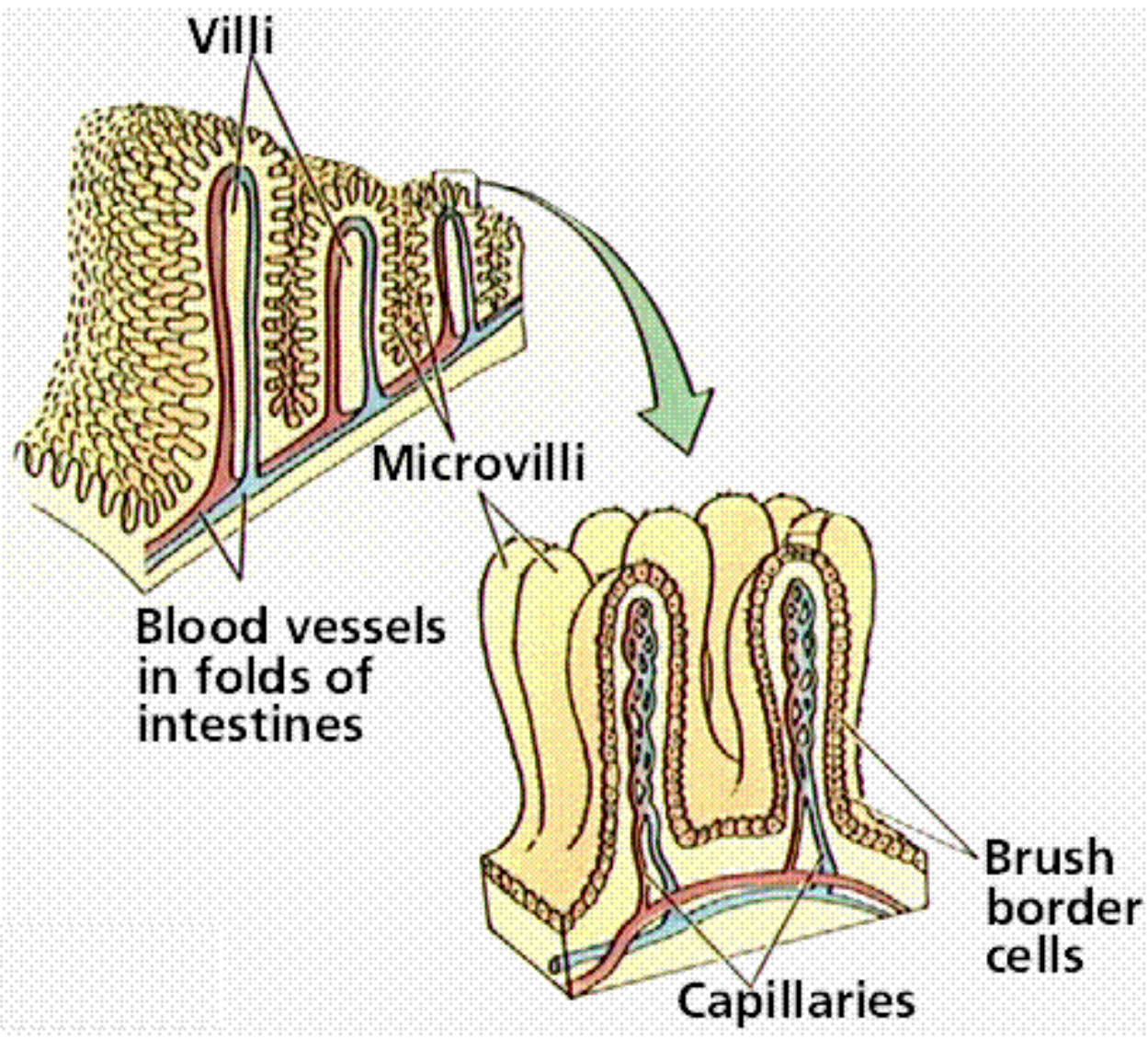
M/38  
COLONOSCOPY

CRAHER  
SFMC



<b>WWTP</b>	<b>Human</b>
<b>Headworks - Communitor</b>	<b>Teeth</b>
<b>Primary Clarifier - separating liquid from solids - Preping for secondary treatment</b>	<b>Stomach - Separating liquid and solids</b> <b>Prepping solid food for digestion</b> <b>Acid bath and enzymes to break down food</b> <b>HRT - 2 to 6 hours</b>

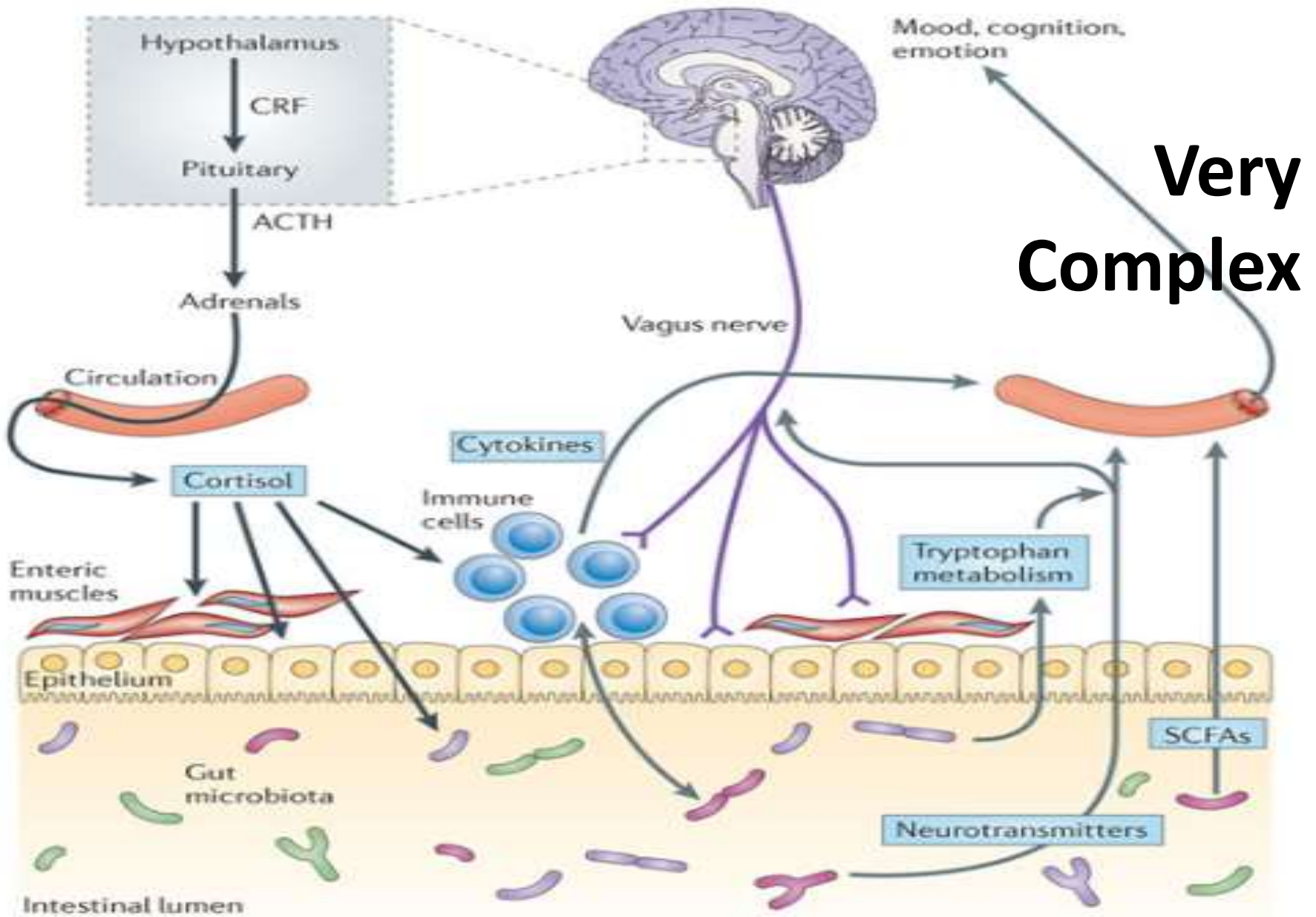
WWTP	Human
<p><b>Secondary Treatment - Attached and/or Suspended Growth (Activated Sludge)</b></p>	<p><b>Small Intestine - about 20 feet long</b> <b>Surface covered with VILLI &amp; MicroVILLI</b> <b>20,000 projections per sq. inch - Surface area of tennis court</b> <b>About 100X greater than our skin</b> <b>Movement via PERISTALIC WAVE</b> <b>Just ahead of intestine - liver/pancreas - adds digestive juices</b> <b>Final break down of food,</b> <b>all dissolved readily available nutrients are absorbed</b> <b>provide energy directly to us</b> <b>all absorbed nutrients go directly into the blood stream</b> <b>and immediately flows through the liver (filtering)</b> <b>Limited Microbe population - those who feed on simple carbs</b> <b>HRT - 3 to 5 hours</b></p>



# Small Intestine Villi & Microvilli

<b>WWTP</b>	<b>Human</b>
<b>Sludge Treatment, Stabilization and Dewatering</b>	<p><b>Colon</b> - about 3 feet long</p> <ol style="list-style-type: none"><li>1) Recovers water/electrolyte</li><li>2) form/make feces</li><li>3) ferment indigestible food</li></ol> <p>Microbes digest fermentable food particles which were not absorbed in the small intestine</p> <p>Fermenting products are SCFA, Vitamins K, B12, B1, B2</p> <p>About 20 different hormones produced by gut</p> <p>These products are absorbed through colon wall into blood then liver</p> <p>All but the last few inches which don't go to liver (Hench suppositories)</p> <p>Most of our microbes live in Colon</p> <p>2/3 immune system trained in gut</p> <p>Immune System is linked closely with microbes</p> <p><b>HRT 4 to 72 hours (3 days)</b></p>

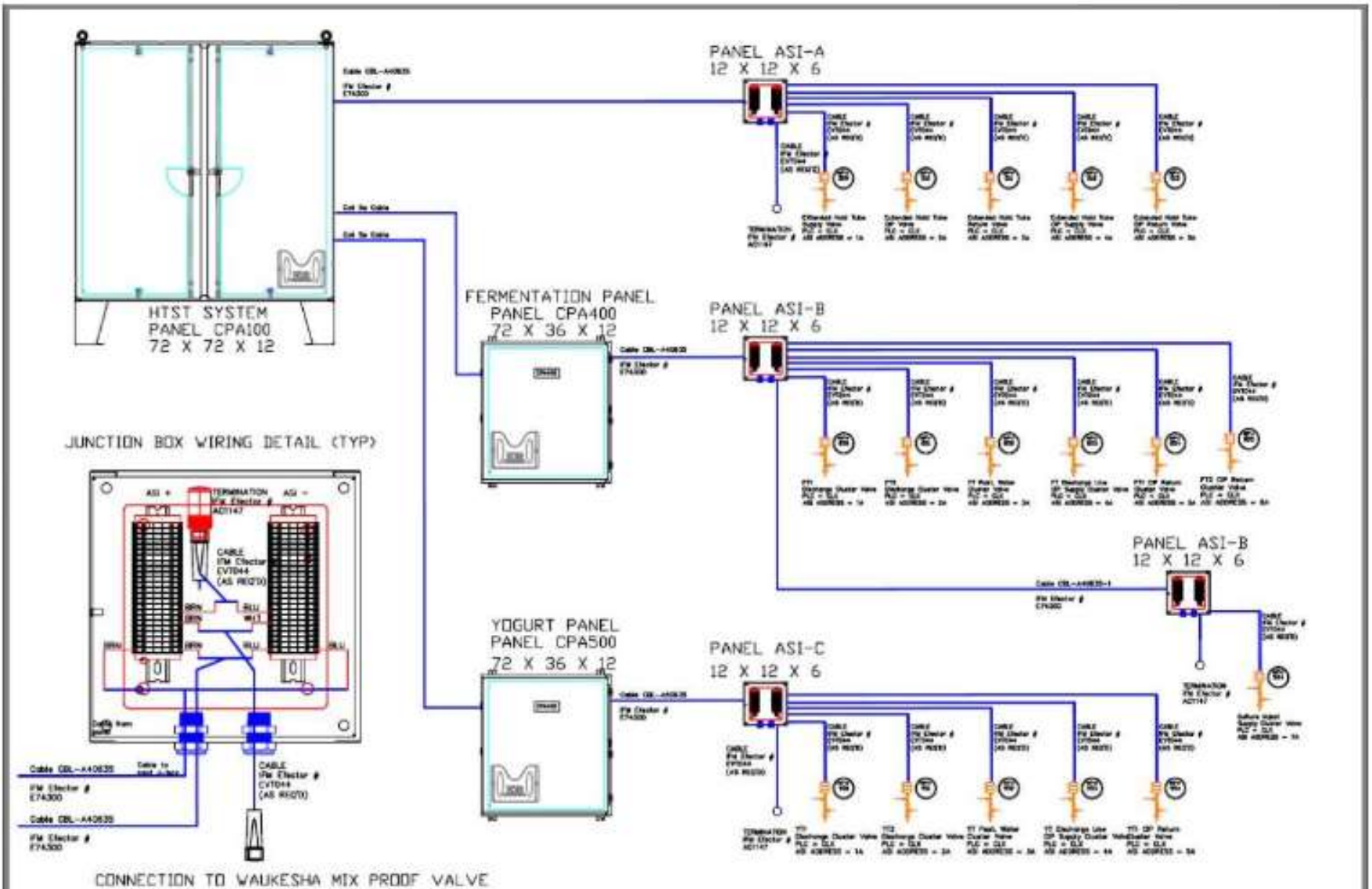
WWTP	Human
<b>Disinfection</b>	<p><b>Immune System</b> - "Our immune system is a 'reactive system' of white blood cells constantly on alert to keep invaders out. When our immune system is weakened, an invader can get through causing us to fall ill." - <a href="http://HealthPrep.com">HealthPrep.com</a></p> <p>"Is a complex system of cellular and molecular components whose <u>primary function</u> is <b>distinguishing self from nonself</b> and defense against foreign organisms or substances." <a href="http://TheFreeDictionary.com">The FreeDictionary.com</a></p>




**Very  
Complex**

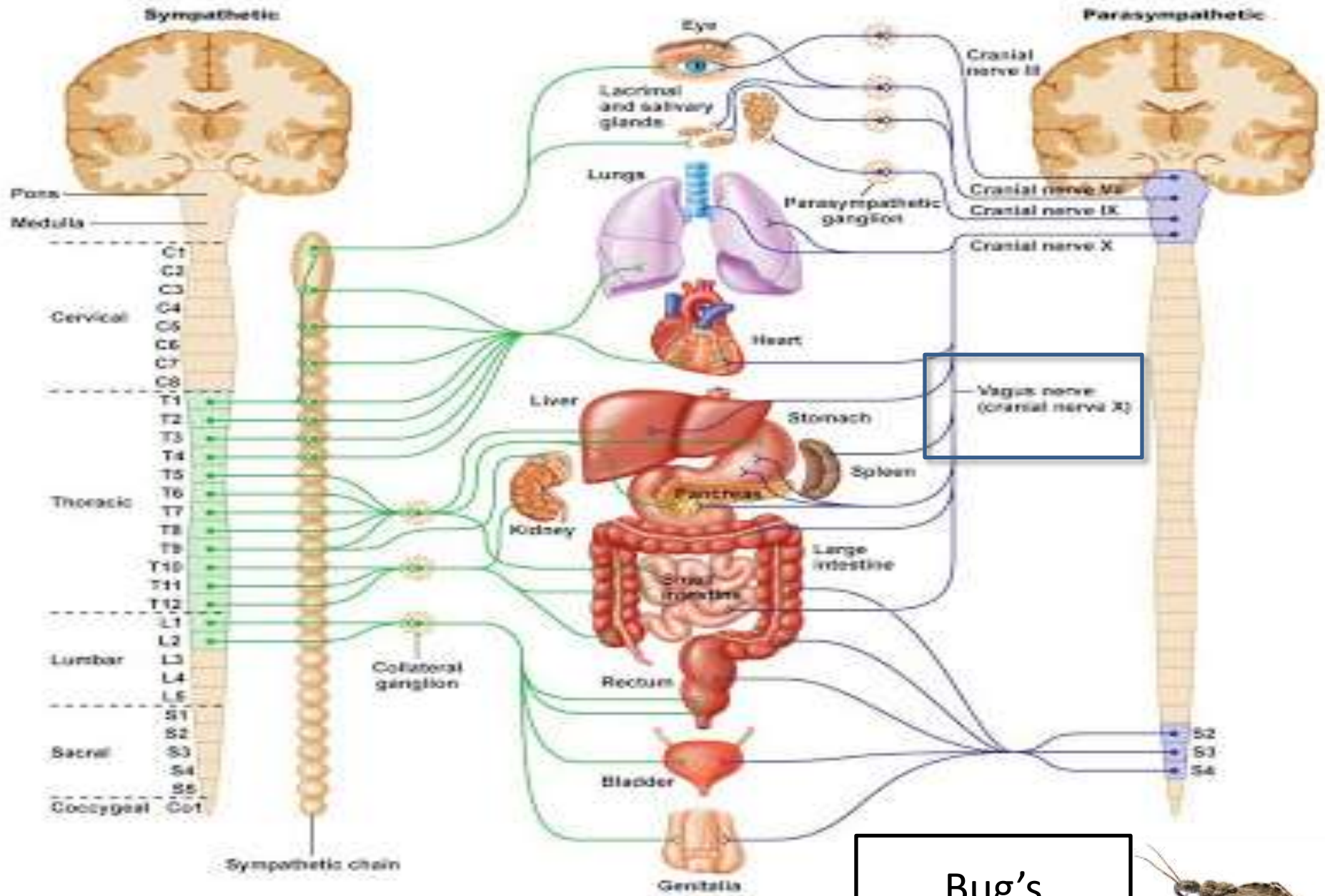
Gut bugs TRAIN immune system

WWTP	Human
<p>SCADA including PLCs, HMIs, Computers and Sensors and Controls</p>	<p><b>Vagus Nerve</b> - It is the longest cranial nerve. It contains motor and sensory fibers. It connects the brain to airways, lungs, heart, blood vessels in heart/lungs/gut, liver, stomach &amp; small intestine, pancreas and enteric nervous system. <b>Enteric nervous system is it own nervous system controlling digestive tract - from esophagus to anus</b> <a href="http://www.vivo.colostate.edu">www.vivo.colostate.edu</a></p>



ACME CHEESE Biscox, NC		Number of Sites: 3	Start Date: 3	Drawn By: SPM		Drawing Number: ASi-NET
ASI NETWORK CONNECTION Network Connection		Project Number: AT2362	File Name: ASi-NET.dwg	Creation Date: 09/29/2014		Revision: A





COMPARING  
MICROBE  
MANAGEMENT TO  
PRODUCE DESIRED  
RESULTS

# WHAT RESULTS ARE WE LOOKING FOR?

**WWTP – High Quality  
Effluent & Biosolids**

**Human Gut Microbiome –  
Good Physical & Mental Health  
by Controlling Inflammation**

**What is and Where do We Get  
Inflammation ? (Swelling/Fever)**

# List of Autoimmune Disease Due to Inflammation

ALLERGIES/ASTHMA  
BEHAVIORAL & MOOD DISORDERS  
CHRONIC HEADACHES  
MULTIPLE SCLEROSIS  
ADHD  
DEMENTIA  
ACID REFLUX  
CELIAC  
CROHN'S  
DIABETES  
ARTHRITIS  
INSOMNIA  
CHRONIC LYME'S  
THYROID CONDITIONS  
OVERWEIGHT & OBESITY  
NEUROPATHIES  
MEMORY PROBLEMS

GP

*This is only a partial list -  
some lists up to 159  
autoimmune diseases*

*Distinguishing Self  
from Non-self*

# First Off.....

## Who Are We Feeding?

### WWTP

- Microbes in the Secondary treatment processes - suspended or attached growth biological systems
- Aerobic & Anaerobic digester microbes

### HUMANS

- **Us** - we absorb nutrients and glucose - small intestine
- Our Guests Gut **Microbes** ferment food into SCFAs, vitamins & hormones for them & US

# How are WWTP biological processes similar to human microbiome?

- Monitoring
- Environmental Controls
  - Good Feed
- Bugs Relying on Bugs
- Jump Starting Populations
  - Troubleshooting

# Monitoring

- **Keep records**
- **Lab testing (operating parameters & blood/urine)**
- **Observe physical signs**
  - **Foam/Scum**
  - **Smells**
  - **Color**



There are STOOL COLOR charts too – to help figure out what is going on inside

# BRISTOL STOOL CHART

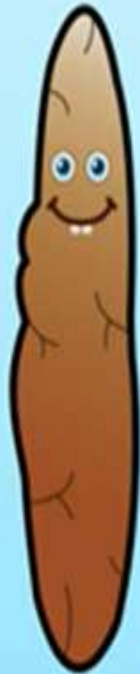
TYPE 1



TYPE 2



TYPE 3



TYPE 4



TYPE 5



TYPE 6



TYPE 7





# Environmental Controls

- **Feeding ratio**
- **How long in gut (vessel)**
- **Nutrient ratio**
- **Stress - lack of  $O_2$  - both WWTP and human**
- **Respiration - Exercise..human's circulation and D.O. - Blowers**
- **Alkalinity, pH and Temperature**

<b>Bioreactor Type</b>	<b>Low HRT</b>	<b>Design (Normal) HRT</b>	<b>High HRT</b>
<b>Anaerobic Digester</b>	Poor treatment doesn't meet vector attraction limits, sludge smells sour	Meet vector attraction limits, sludge smells earthy	Not many gains in treatment over and above Design, complete treatment – maximum gas production
<b>Activated Sludge</b>	Poor settling, less efficient BOD/TSS/Ammonia treatment	Good settling, efficient BOD/TSS/Ammonia removal	Poor settling, large floc which can break into very fine floc
<b>Human</b>	Diarrhea – 10 hrs. Cramping, sore anus, depression, mental issues	1 day, NO bloating, normal amount of gas (minimally odorous)	Constipation – > 2 to 3 days excessive gas and bloating

# Controlling How Long Microbes Stay in the Gut

- **Diet** – eating plenty of vegetable fiber (not wheat fiber)
- **Hydration** – Drink enough water
- **Reduce/Eliminate** – Refined foods, grains/starches/sugar
- **Supplements**
  - Probiotics
  - Vitamins/mineral deficiencies....
    - **MAGNESIUM** & vitamin D are common
  - Cleanse Products
- **Stools** - Some say – have minimum **one per day** may be two – achieve through eating fiber, probiotics and hydration

# High Fiber

- FYI - Personal experience – **NOT Wheat bread** *but* **VEGETABLES**.....best source of fiber (Some whole fruit too)
- Countries eating **high veggie diet** have;
  - More **diverse** microbiome
  - Less inflammation related diseases
- **Diversity of vegetable/fruit** eaten will determine the **diversity** level of the **microbes**
- Vegetables have microbes on them - these microbes know how to consume these veggies in an anaerobic environment (colon)

# Feed Them Well

- **Balanced BOD:N:P to provide for healthy microbe growth**
- **Control - What organisms grow based on environmental conditions setup**
- **Personal experiment - Real food (not processed) - High veggies  $\frac{1}{2}$  to  $\frac{3}{4}$  of plate, the rest of plate is whole fruit, “Good” fats and protein - Fuel - Fats vs. Carbs (anaerobic digester)**

# Bugs Relying on Bugs (And/or Human)

- **Anaerobic Digester - bugs produce VFAs → VFA food for methanogens**
- **Anaerobic Zone in Bio-P - bugs ferment rbCOD to VFA → for PAOs**
- **In colon the microbes are producing vitamins that both we and other microbes are using**
- **Microbes are busy manufacturing SCFAs, vitamins and hormones for their human host**

# Jump Starting Populations

- Starting up new anaerobic digester or new activated started - **SEED** from another WWTP
- How to fix badly broken gut microbiome - **fecal transplant**
- How to fix an out of imbalance gut microbiome - Cleanse/Change Feeding-Sleep-Exercise/**Probiotic**

# Troubleshooting Examples



# Fundamental Experiments in Microbiology

Crabtree, Koby T.

Note: This is not the actual book cover

# Wastewater Microbiology

A Handbook for Operators

Toni Glymph

American Water Works Association  
The Association of Municipalities of North America

3rd Edition

# MANUAL on the CAUSES and CONTROL of ACTIVATED SLUDGE BULKING, FOAMING, and OTHER SOLIDS SEPARATION PROBLEMS

David Jenkins  
Michael G. Richard  
Glen T. Daigger

also available as a printed book  
see title verso for ISBN details



# Koby Crabtree, Dr. Jenkins, Tony Glymph

## WHAT DO ALL THESE FOLKS TEACH US?

- ID organisms to understand source of the problem
  - Vs. struggling with the problem and/or putting a Band-Aid on it – chlorinate
- DNA sequencing has accelerated the understanding of wastewater biomasses and the **HUMAN MICROBIOME**



**MICROBE**  
DETECTIVES

**What's Living in Your Water?™**

[Order Microbiome Evaluation](#) 

METAGENOMICS • DATA SCIENCE • BIOBANKING

# Sequencing a Microbiome

uBiome Explorer

Microbiome Explorer

Questionnaires My Samples

Sample Type

Date

Gut

11/06/2017

Insights

Probiotics

Timeline

Compare

My Bacteria

Advanced ▼

PHYLUM



CLASS



ORDER



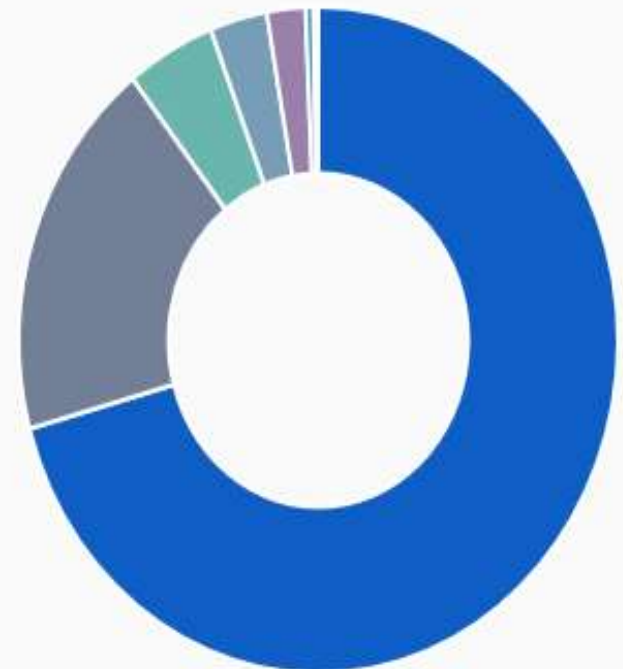
FAMILY



GENUS

Bacteria at the Phylum rank

Firmicutes:	70.72%
Bacteroidetes:	18.63%
Proteobacteria:	4.80%
Verrucomicrobia:	3.09%
Actinobacteria:	2.08%
Lentisphaerae:	0.44%
Spirochaetes:	0.21%
Tenericutes:	0.04%




# Sequencing a Microbiome

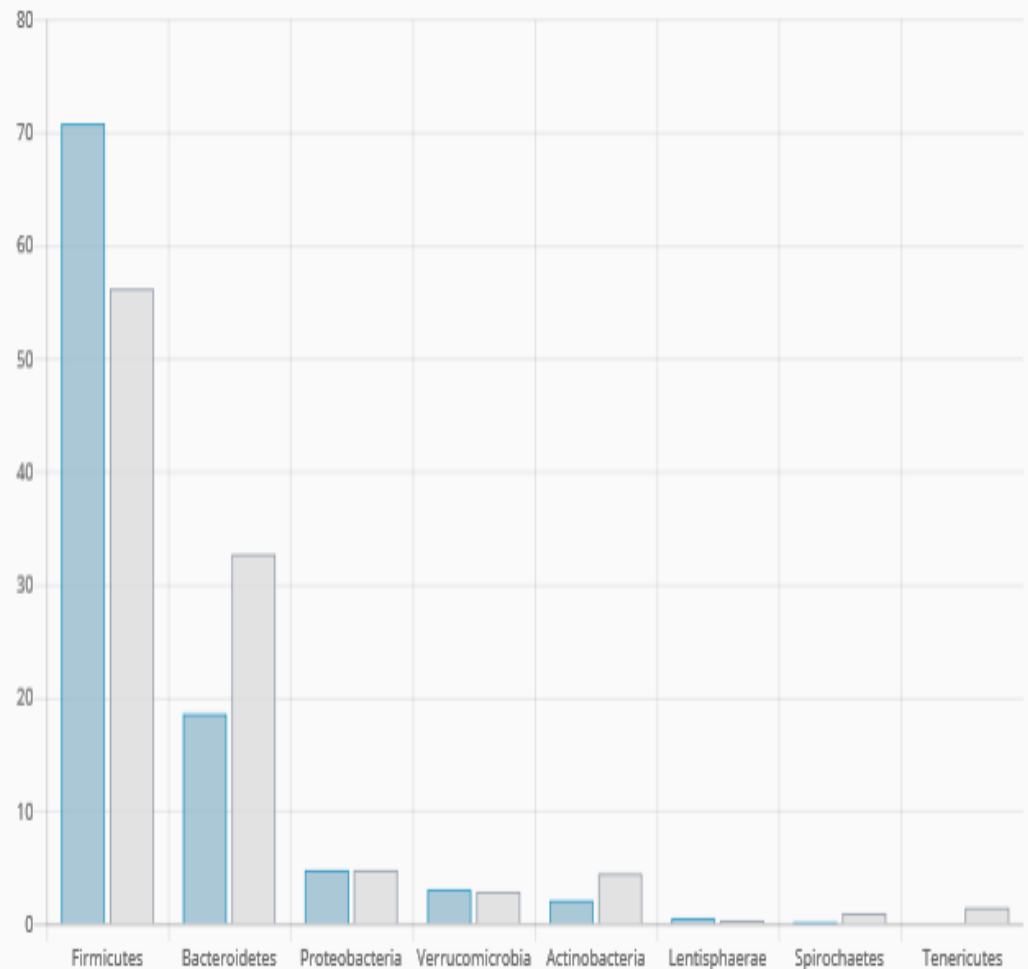


Your Bacteria at the Phylum rank compared to All Samples

Bacteria	Ratio
Firmicutes	1.26 X
Bacteroidetes	0.57 X
Proteobacteria	1.02 X
Verrucomicrobia	1.11 X
Actinobacteria	0.46 X
Lentisphaerae	1.46 X
Spirochaetes	0.21 X
Tenericutes	0.03 X

Your sample compared to the average of all samples of this type.

Graph Key  
Your Sample:   
Comparison: 



# SLiME BULKiNG

Poor activated sludge settling condition due to exocellular slime in the sludge – which make for sludge that does not compact well

# Tony Glymph-Martin

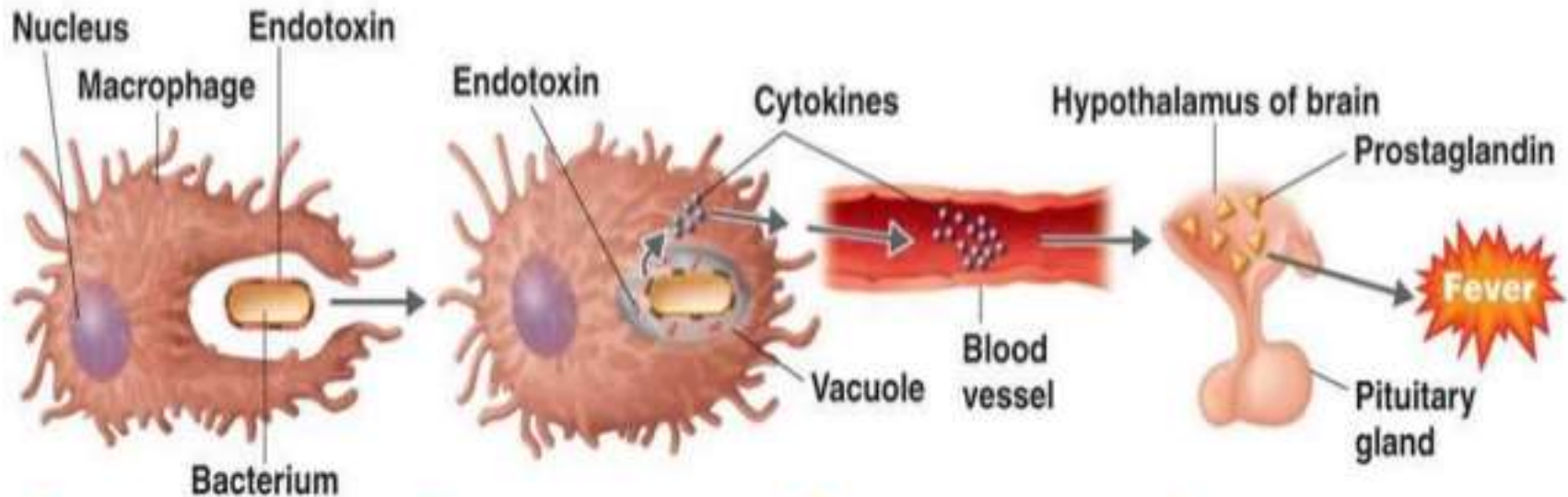
- Under low food/low nutrient conditions bacteria secrete EXCESS lipopolysaccharide (LPS)
- The more starved they are, the more they secrete
- If LPS coating is **HIGH** or **EXCESSIVE** this can mean a nutrient deficiency or a recent toxic shock or high BOD loading(High BOD without enough nutrients)

# LPS in Humans

- LPS is an **ENDOTOXIN**
  - Poisonous substance present in bacteria but separable from the cell body only on its disintegration
- LPS causes
  - Inflammation in the gut
  - Gut leak
  - In blood stream causes
    - Immune response is inflammation
    - NO tissue or organ is immune to effects of LPS
    - Can enter brain
    - Enter joints – cause arthritis
    - Mental depression
- If we eat a diet low in nutrients – HIGH CARBON
  - Do our microbes build up more LPS?



# Mechanism of Endotoxin activity



**1** A macrophage ingests a gram-negative bacterium.

**2** The bacterium is degraded in a vacuole, releasing endotoxins that induce the macrophage to produce cytokines IL-1 and TNF- $\alpha$ .

**3** The cytokines are released into the bloodstream by the macrophages, through which they travel to the hypothalamus of the brain.

**4** The cytokines induce the hypothalamus to produce prostaglandins, which reset the body's "thermostat" to a higher temperature, producing fever.

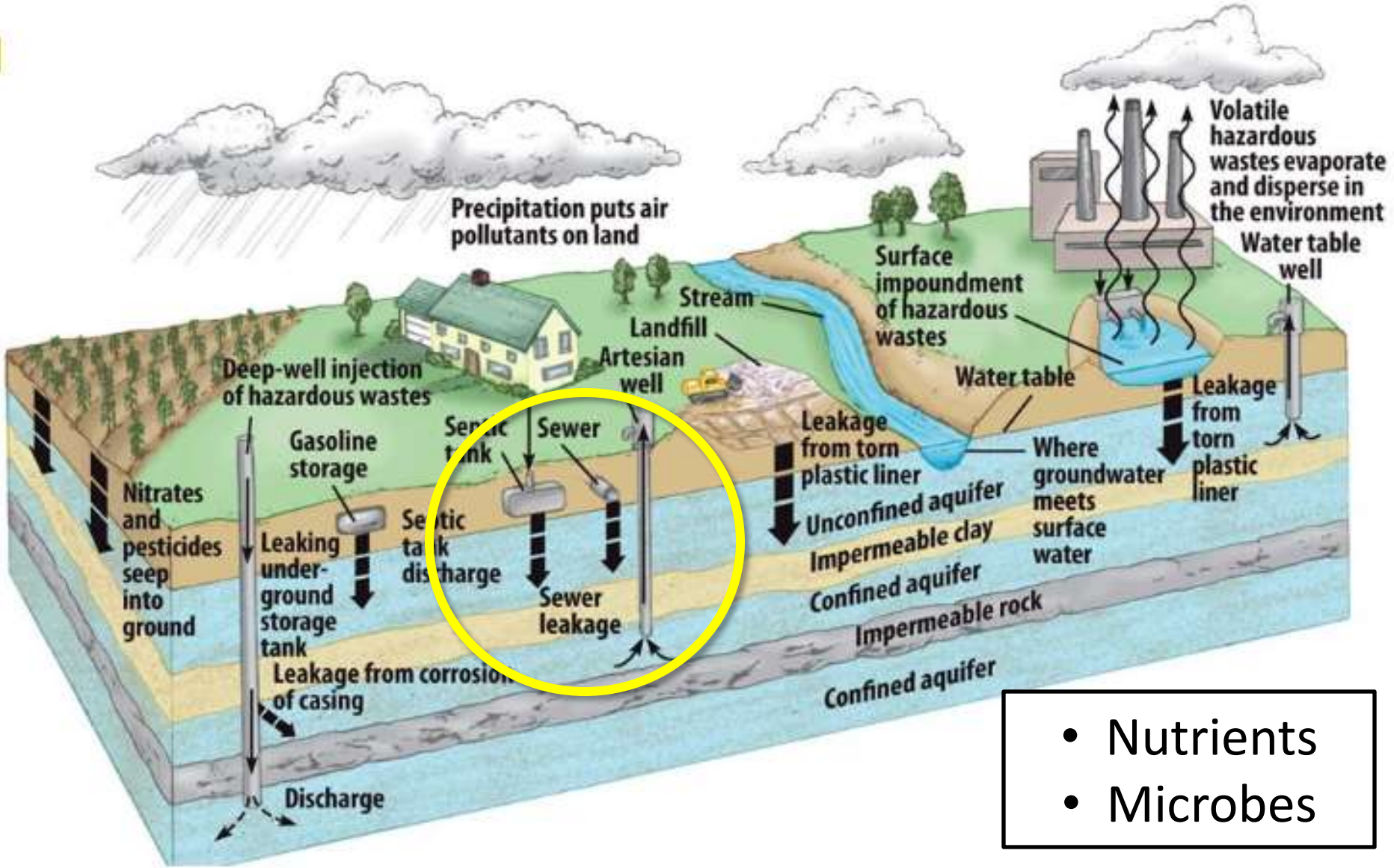
# Low Nutrient & Low Dietary Fiber Diets - Starve Bugs in Colon

- Low fiber foods (sugars/starches) are easily digested (absorbed) in the small intestine
- Nothing left over for Microbes in colon – they starve
- To survive - Microbes use the **PROTECTIVE MUCUS** in colon as food, Mucus layer serves
  - To protect colon wall
  - Help with lubrication for stool movements

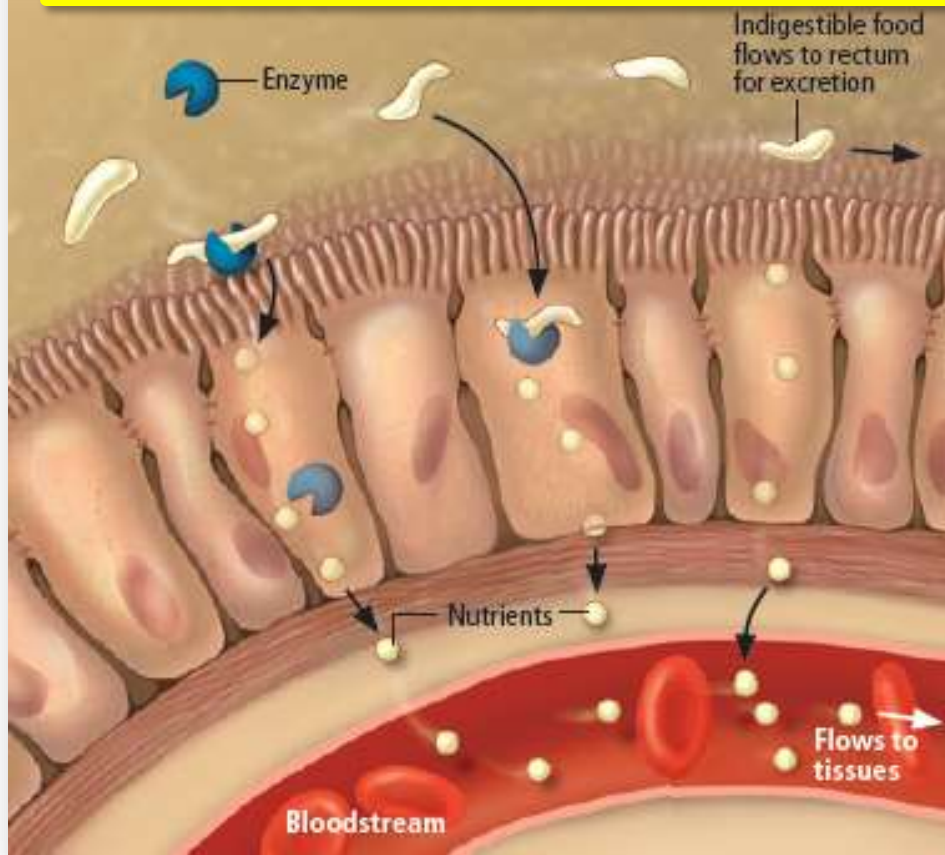
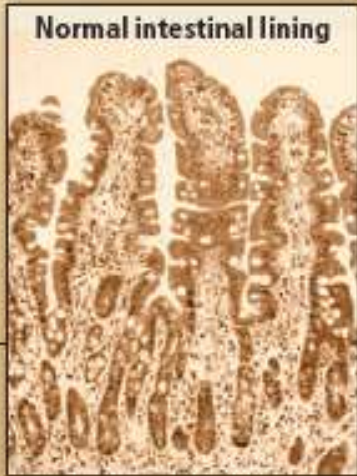
# Leaky Sewers

Also Leaks from tanks and pipe at WWTP  
All of these are cause for concern due to  
ground water contamination  
Out of Sight Out Mind!!! – **HARD TO DETECT**

# Groundwater Pollution



- Nutrients
- Microbes



# Surprises from Celiac Disease

*Study of a potentially  
fatal food-triggered  
disease*

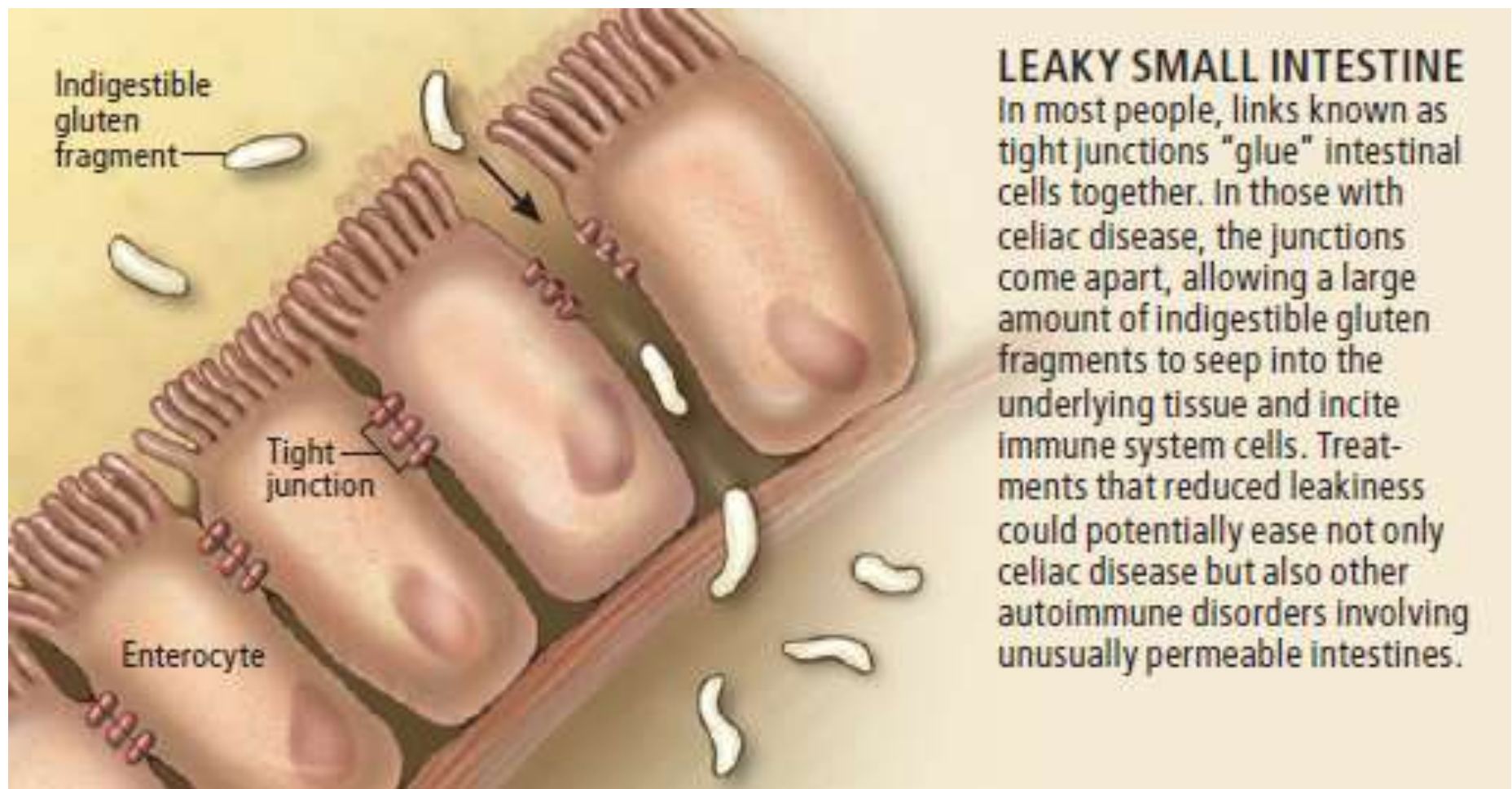
*has uncovered a  
process that may  
contribute to many  
autoimmune disorders*

**By Alessio Fasano**

Sept 2009

OLD NOW

OUT OF SIGHT OUT OF MIND !!!



# Surprises from Celiac Disease

By **Alessio Fasano**

# Zonulin

- Protein which modulates permeability of **tight junctions** between cells of the wall of the digestive tract.
- Discovered in **2000** by Alessio Fasano and his team at the University of Maryland School of Medicine
- **Gluten** (and other invaders [**LECTINS**]) can **stimulate** the **production** of Zonulin creating **GUT LEAK**
- *Late 1980s Dr. Fasano worked on a **vaccine for cholera** (bad diarrhea). Didn't work – continued work and found zonulin & leaky gut*

# 4 Ways Grains Can Cause Gut Damage.....

1. **Direct inflammation** – change balance between friendly and unfriendly microbes
2. Can cause **intestinal permeability** (leaky gut) - **zonulin**
3. It is **difficult to digest**, as well as containing proteins
  - Inhibit digestion of other food
  - Resulting in fermentation in gut, that creates
    - ☐ Gas / Bloating / Pain /other IBS symptoms
4. **Change healthy bacteria** which can contribute to a host of problems (**LPS???**) including leaky gut, yeast overgrowth, and disrupted digestion and absorption





# Recent wheat history

- Olden Days – millstones grind into a meal
- Kernel of wheat - made up of;
  - **Endosperm** - **simple starches** – food to feed a new plant
  - **Bran** – hard shell coating the kernel - **fiber**
  - **Germ** - fat-filled reproductive organ that also contains **fiber**, germinates to create a new plant



# Recent wheat history

- Industrial Age Refined wheat – **WHITE FOUR**
  - Problem – Keeping large volumes fresh in **storage**
  - Fix - Remove the oily **Germ** – which contains;
    - High dietary fiber
    - healthful micronutrients
  - Also remove **Bran** → White fluffy flour
  - Better looking/tasty/easier to bake
- Refined wheat created health problems
  - Vitamin deficiency – fortification rules came into being

# Celiac vs. Gluten Sensitivity

Celiac is an **Acute** reaction to gluten

Gluten sensitivity – Can be Acute or Chronic (in varying degrees)

- Everyone is impacted by gluten (lectins) - ZONULIN
  - There is s a spectrum to the sensitivity
  - Some **not so much**
  - Others **a lot more**
  - With **age** Issue INCREASES
- As we age problem intensifies

# Gut Leak

- Gluten (wheat, rye, barley) stimulates genes for gut leak – some say “all grains” or “lectins”
- **“Loss of Oral Tolerance”**
- When your gut (small intestine) can **no longer tolerate the insults** gluten\* has given it then your gut starts leaking

\* or other foods you are sensitive to

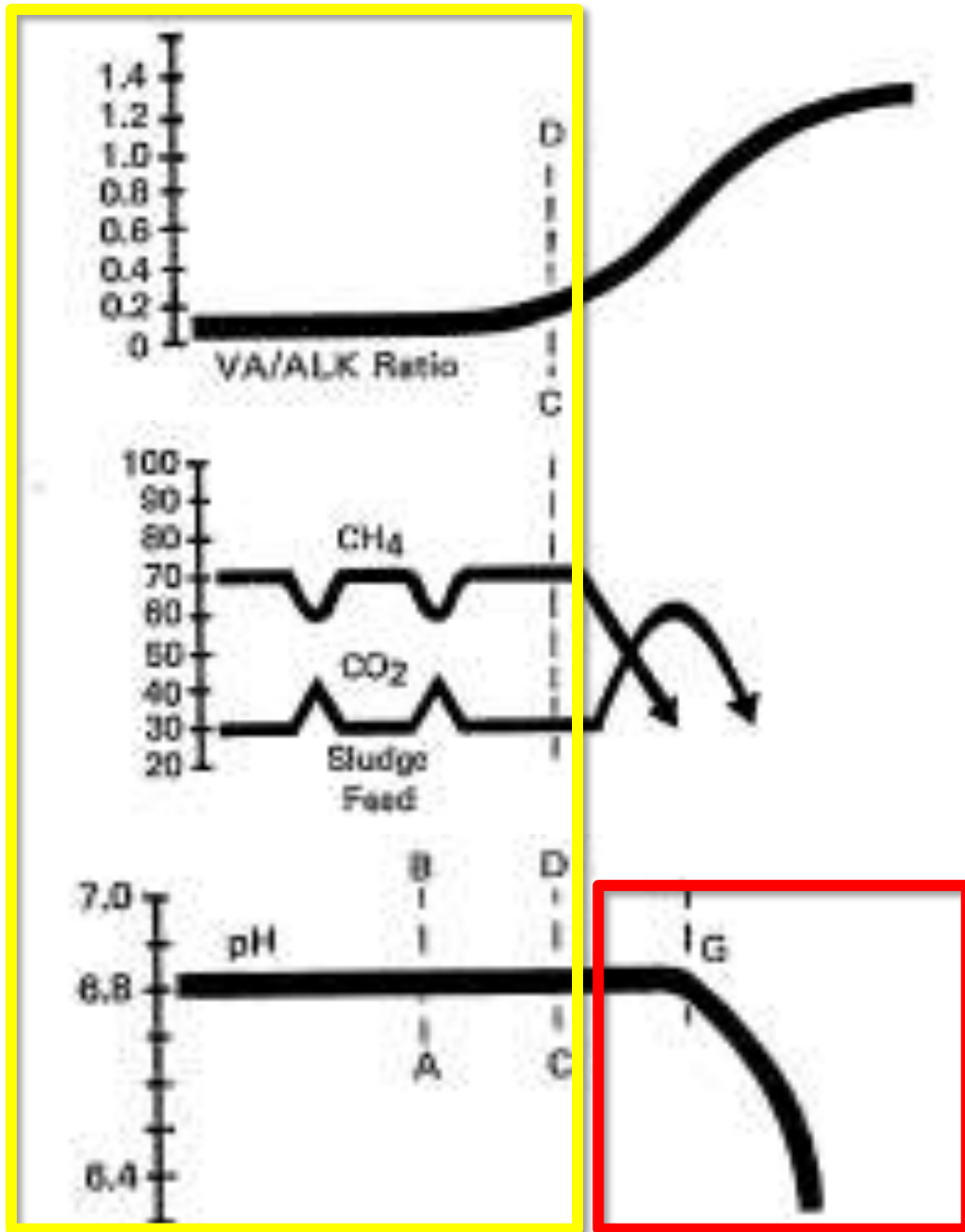
# SOUR ANAEROBIC DIGESTER

When we over feed an anaerobic digester  
we create a imbalance between ACID &  
METHANE producing microbes and it  
performance drops

# Anaerobic Digesters

If you test the right parameters you can see that it is going bad

Predictive  
Autoimmunity  
Test Antibodies





Discovers – There is a **Spectrum for a Disease**  
Lupus does not just show up one day or some other autoimmune disease, it comes on gradually unnoticed over time - before you feel it

# SPECTRUM OF AUTOIMMUNITY

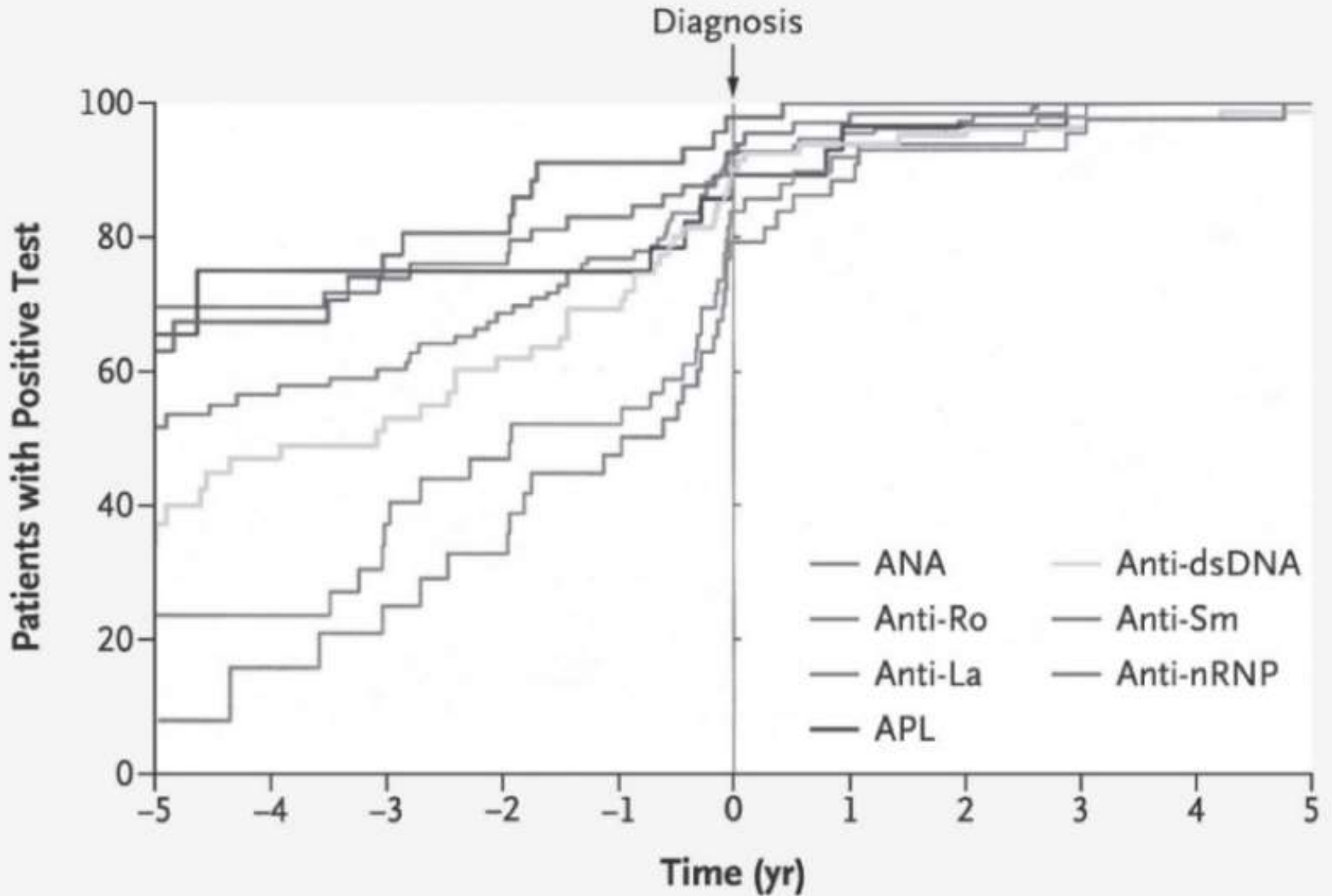
- Dr. Melissa Arbuckle study 2003
- 130 veterans in VA – diagnosed with lupus
- US government – freezing/saving blood samples seen 1978
- Antibodies measured

**Distinguishing Self from Non-self**

From: Autoimmune Fix by Tom O'Bryan



# Lupus Study



# PATHWAY IN DEVELOPING AUTOIMMUNE DISEASE

Cellular Damage →

Tissue Damage →

Organ Inflammation →

Organ Damage → Symptoms →

Finally Diagnosed Disease

# Autoimmune Reaction Causes a Cascade

- A series of chemical or physiological processes that occur in successive stages, each of which is dependent on the preceding one, to produce a culminating effect. The steps involved in the clotting of blood occur as a cascade.
- **You fix it by turning off what starts the cascade**

WHAT AN INCREDIBLE  
CONNECTED STORY UP & DOWN  
STREAM FROM HERE !!!



# Gut Bug Connection

- We all routinely manipulate and optimize **MICROBE POPULATIONS** in our **treatment processes** to produce excellent effluent and high quality biosolids
- You also can manipulate and optimize the **SAME MICROBES** who **reside in us** to produce good physical and mental health

# Overall

- **God's amazing creation**
  - The human being
  - Partnering with a real adaptable  
microbe population
- **The Amazing BIO-chemical  
Mechanical Design**

**Additional Tidbits**

# Other Factors Impacting Microbes

- Microbes do better when we;
  - Feed them properly
  - Exercise
  - Get enough sleep
  - Manage stress
- Interestingly enough Microbes can help us with two of these
  - Getting sleep
  - Managing stress



# Odds/Ends

- Microbe producing SCFA in the colon - Make us feel full longer so we consume less calories
- **Sleep** – Time for body wide **repairs**
- Study showed – takes **17 yrs.** from discovery to being ***put into practice***
- Functional Medicine
- **Firmicutes/Bacteroidetes** – Need right balance more Bacteroidetes
- **Human cells are constantly being replaced**
  - Some faster and some slower – reason long time frame

# Odds/Ends

- **Probiotics**
  - They help – in fermented foods/capsules
  - You need to keep taking them to provide benefit
  - Helps with regular “Daily Constitution”
  - Helps to fix leaky gut and - **In taking up space – vs. bad guys**
- **Gene Expression – Field of Epigenetics**
  - Genes do not doom us to a specific disease
  - **Genes are like switches** – we turn them **ON/OFF** by what **we put in/on our bodies** & how we treat our bodies – sleep/exercise/stress

Please Don't Take My Word on  
These Important Issues  
Instead - Just Like in Managing Your  
Microbes Your Activated Sludge  
**Investigate on Your Own**  
Get a Better Understanding of Your  
Own Microbe Population and How  
to Manage it for BETTER Physical &  
Mental

# Credits

- Various images clipped from internet
- Tools & Tips – Iowa Rural Water (Tony Glymph)
- The Autoimmune Fix - Tom O’Bryan DC CCN DACBN
- The Daniel Plan - Rick Warren D.MIN, Daniel Amen M.D., Mark Hyman M.D.
- The Good Gut – Justin Sonnenburg PhD, Erica Sonnenburg PhD
- The Microbiome Diet – Raphael Kellman M.D.
- Brain Maker & Grain Brain – David Perlmutter M.D.
- No Grain, No Pain – Peter Osborne Doctor of pastoral science, Board Certified Clinical Nutritionist
- It Starts with Food – Melissa & Dallas Hartwig
- Surprises from Celiac Disease: Scientific American – Alessio Fasano M.D.
- Eat Dirt – Josh Axe DNM, DC, CNS
- Gut – Giulia Enders
- Change Your Brain, Change your Life – Daniel Amen M.D.
- Wheat Belly – William Davis M.D.
- The Plant Paradox – Steven R. Gundry M.D.
- The Magnesium Miracle – Carolyn Dean M.D.