The Gut Bug Connection

By Greg Paul

This talk is not meant as medical advice – just sharing information

WARNING
This Talk is Not for the Weak of Stomach
Sorry it Had to Be at Breakfast

Sitting through this talk right after breakfast is a test to see what we operators are really made of!!!!
Let’s take a deep dive into similarities between WWTP and the gut.

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
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
Pinch Valve and Pooping

Side Note
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

Squatty Potty
Physical Comparison: Sewer/WWTP to Human Digestive System
<table>
<thead>
<tr>
<th>SEWER</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitary Sewer System</td>
<td>One Pipe - Various Jobs</td>
</tr>
<tr>
<td></td>
<td><strong>Esophagus</strong> - transporting food/liquid to Stomach</td>
</tr>
<tr>
<td></td>
<td><strong>Stomach</strong> - Prep food for digestion</td>
</tr>
<tr>
<td></td>
<td><strong>Small Intestine</strong> - Absorb nutrients</td>
</tr>
<tr>
<td></td>
<td><strong>Colon</strong> - Dewater waste, produce fermented products recycle water/electrolytes</td>
</tr>
<tr>
<td></td>
<td><strong>Total of 25 to 30 Feet Long</strong></td>
</tr>
<tr>
<td></td>
<td><strong>HRT</strong> - 9 hours (or less) to 3.5 Days +</td>
</tr>
</tbody>
</table>

**BOTH - OUT OF SIGHT OUT OF MIND**

**CMOM** WAS INVENTED TO DEAL WITH THIS COMMON PROBLEM
<table>
<thead>
<tr>
<th>WWTP</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headworks - Communitor</td>
<td>Teeth</td>
</tr>
<tr>
<td>Primary Clarifier - separating liquid from solids - Preping for secondary treatment</td>
<td><strong>Stomach</strong> - Separating liquid and solids</td>
</tr>
<tr>
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</tbody>
</table>
Stomach
<table>
<thead>
<tr>
<th>WWTP</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Treatment - Attached and/or Suspended Growth (Activated Sludge)</td>
<td>Small Intestine - about 20 feet long</td>
</tr>
<tr>
<td></td>
<td>Surface covered with VILLI &amp; MicroVILLI</td>
</tr>
<tr>
<td></td>
<td>20,000 projections per sq. inch - Surface area of tennis court</td>
</tr>
<tr>
<td></td>
<td>About 100X greater than our skin</td>
</tr>
<tr>
<td></td>
<td>Movement via PERISTALIC WAVE</td>
</tr>
<tr>
<td></td>
<td>Just ahead of intestine - liver/pancreas - adds digestive juices</td>
</tr>
<tr>
<td></td>
<td>Final break down of food,</td>
</tr>
<tr>
<td></td>
<td>all dissolved readily available nutrients are absorbed</td>
</tr>
<tr>
<td></td>
<td>provide energy directly to us</td>
</tr>
<tr>
<td></td>
<td>all absorbed nutrients go directly into the blood stream</td>
</tr>
<tr>
<td></td>
<td>and immediately flows through the liver (filtering)</td>
</tr>
<tr>
<td></td>
<td>Limited Microbe population - those who feed on simple carbs</td>
</tr>
<tr>
<td></td>
<td>HRT - 3 to 5 hours</td>
</tr>
</tbody>
</table>
Small Intestine

Villi & Microvilli

Blood vessels in folds of intestines

Capillaries

Brush border cells
<table>
<thead>
<tr>
<th>WWTP</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sludge Treatment, Stabilization and Dewatering</strong></td>
<td><strong>Colon</strong> - about 3 feet long</td>
</tr>
<tr>
<td></td>
<td>1) Recovers water/electrolyte</td>
</tr>
<tr>
<td></td>
<td>2) Form/make feces</td>
</tr>
<tr>
<td></td>
<td>3) Ferment indigestible food</td>
</tr>
<tr>
<td></td>
<td>Microbes digest fermentable food particles which were not absorbed in the small intestine</td>
</tr>
<tr>
<td></td>
<td>Fermenting products are SCFA, Vitamins K, B12, B1, B2</td>
</tr>
<tr>
<td></td>
<td>About 20 different hormones produced by gut</td>
</tr>
<tr>
<td></td>
<td>These products are absorbed through colon wall into blood then liver</td>
</tr>
<tr>
<td></td>
<td>All but the last few inches which don't go to liver (Hench suppositories)</td>
</tr>
<tr>
<td></td>
<td>Most of our microbes live in Colon</td>
</tr>
<tr>
<td></td>
<td>2/3 immune system trained in gut</td>
</tr>
<tr>
<td></td>
<td>Immune System is linked closely with microbes</td>
</tr>
<tr>
<td></td>
<td>HRT 4 to 72 hours (3 days)</td>
</tr>
</tbody>
</table>
Again from the family photo album
JUST Like Televising Sewers
<table>
<thead>
<tr>
<th>WWTP</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfection</td>
<td><strong>Immune System</strong> - &quot;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.&quot; - HealthPrep.com</td>
</tr>
<tr>
<td></td>
<td>&quot;Is a complex system of cellular and molecular components whose <strong>primary function is distinguishing self from nonself</strong> and defense against foreign organisms or substances.&quot; - The FreeDictionary.com</td>
</tr>
</tbody>
</table>
Very Complex
<table>
<thead>
<tr>
<th>WWTP</th>
<th>Human</th>
</tr>
</thead>
</table>
| **SCADA including PLCs, HMIs, Computers and Sensors and Controls** | **Vagus Nerve** - 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 & small intestine,  
pancreas and enteric nervous system.  
Enteric nervous system is it own nervous system controlling digestive tract - from esophagus to anus |

www.vivo.colostate.edu
Healthy status

Healthy CNS function

Normal gut physiology

Physiological levels of inflammatory cells/mediators
Normal gut microbiota

Stress/disease

Alterations in behaviour, cognition, emotion, nociception

Abnormal gut function

Increased levels of inflammatory cells/mediators
Intestinal dysbiosis
COMPARING MICROBE MANAGEMENT TO PRODUCE 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

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 of operating parameters
- Observe physical signs
  - Foam/Scum
  - Smells
  - Color
There are STOOL COLOR charts too – to help figure out what is going on inside.
Environmental Controls

- HRT, F/M, SRT and Organic Loadings
- Stress – lack of O$_2$ when needed or presence of O$_2$ when not needed – both WWTP and human
- Respiration - Exercise – provide human’s circulation and D.O. – Blowers → D.O. for bugs

Alkalinity, pH and Temperature
<table>
<thead>
<tr>
<th>Bioreactor Type</th>
<th>Low HRT</th>
<th>Design (Normal) HRT</th>
<th>High HRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic Digester</td>
<td>Poor treatment doesn’t meet vector attraction limits, sludge smells sour</td>
<td>Meet vector attraction limits, sludge smells</td>
<td>Not many gains in treatment over and above Design, complete treatment – maximum gas production</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>Poor settling, less efficient BOD/TSS/Ammonia treatment</td>
<td>Good settling, efficient BOD/TSS/Ammonia removal</td>
<td>Poor settling, large floc which can break into very fine floc</td>
</tr>
<tr>
<td>Human</td>
<td>Diarrhea – 10 hrs. Cramping, sore anus, depression, mental issues</td>
<td>1 day, NO bloating, normal amount of gas (minimally odorous)</td>
<td>Constipation – &gt; 2 to 3 days excessive gas and bloating</td>
</tr>
</tbody>
</table>
How do you Control Microbe HRT 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 if deficient (Magnesium & D deficiencies 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
- We have control over what organisms we grow based on what environmental conditions we setup for the bugs
- Personal experiment – Real food (not processed) - High veggies 1/2 to 3/4 of plate, the rest of plate is whole fruit. “Good” fats and
Bugs Relying on Bugs(And/or Human)

- Anaerobic Digester – bugs produce VFAs $\rightarrow$ VFA food for methanogens
- Anaerobic Zone in Bio-P – bugs ferment rbCOD to VFA $\rightarrow$ for PAOs
- In colon the microbes are producing vitamins that both we and other microbes are using
Jump Starting Populations

- How do we get a 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 – **Probiotic/Cleanse/Change**
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
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 Activated Sludge

What causes LPS in WWTP?
Nutrient deficiency and/or toxicity
BOD:N:P – 100:5:1

Looking at our digestive track what causes nutrient deficiency?
High carbon diets – 200:5:1

Why is LPS a problem in human biology?
Causes inflammation in any place within the body
LPS in Activated Sludge

(WWTP BIG Gut)

<table>
<thead>
<tr>
<th>NORMAL CONDITIONS</th>
<th>“P” DEFICIENT</th>
<th>“P” &amp; “N” DEFICIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipopolysaccharide “Slime Layer”</td>
<td>Lipopolysaccharide Slime Layer</td>
<td>Lipopolysaccharide “Slime Layer”</td>
</tr>
<tr>
<td>Phospholipid</td>
<td>“Double lipid”</td>
<td>“Triple Lipid”</td>
</tr>
<tr>
<td>Lipoprotein</td>
<td>Lipoprotein</td>
<td></td>
</tr>
<tr>
<td>Cell Wall</td>
<td>Cell Wall</td>
<td>Cell Wall</td>
</tr>
<tr>
<td>Cell Membrane</td>
<td>Cell Membrane</td>
<td>Cell Membrane</td>
</tr>
</tbody>
</table>
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-α.
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.

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On Low Nutrient & Dietary Fiber Diets

Microbes Starve 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

The Sonnenburgs (P. hDs) - gut microbe research couple
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
LEAKY SMALL INTESTINE

In most people, links known as tight junctions “glue” intestinal cells together. In those with celiac disease, the junctions come apart, allowing a large amount of indigestible gluten fragments to seep into the underlying tissue and incite immune system cells. Treatments that reduced leakiness could potentially ease not only celiac disease but also other autoimmune disorders involving unusually permeable intestines.

Surprises from Celiac Disease
By Alessio Fasano
Zonulin

• A protein that modulates the 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) 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
Discovered Leaky Gut

Fasano, Alessio, MD

- W. Allan Walker Chair in Pediatric Gastroenterology and Nutrition
- Division Chief, Pediatric Gastroenterology and Nutrition; Director, Center for Celiac Research and Treatment
- Director, Mucosal Immunology and Biology Research Center; Associate Chief for Basic, Clinical and Translational Research
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

"No Grain, No Pain: A 30-Day Diet for Eliminating the Root Cause of Chronic Pain" by Peter Osborne
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 - ZONULIN
  - There is a spectrum to the sensitivity
  - Some not so much
  - Others a lot more

- As we age problem intensifies
Gut Leak

- Gluten (wheat, rye, barley) stimulates genes for gut leak – some say “all grains”
- “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

Autoimmune Fix – Tom O’Bryan
When we over feed an anaerobic digester we create a imbalance between ACID & METHANE producing microbes and it performance drops.
If you test the right parameters you can see that it is going bad.

**Anaerobic Digesters**

**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

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

From: Autoimmune Fix by Tom O’Bryan
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 years 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

• A Laboratory Program for Wastewater Microbiology - Tony Glymph-Martin
• 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
• Wheat Belly – William Davis M.D.