

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

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

<http://www.firstcallseptic.com/wp-content/uploads/2012/03/Ronnie-in-Septic-Tank.jpg>

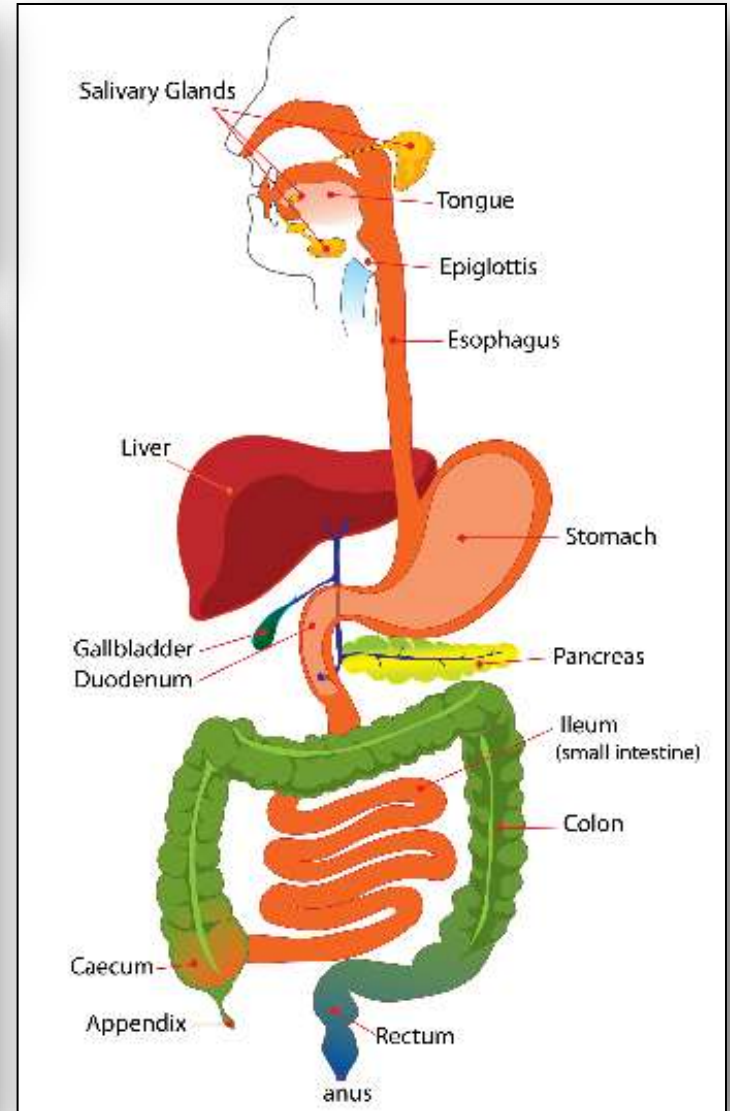
WHAT CONNECTS WWTP & GUT? MICROBES.....

- 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

**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



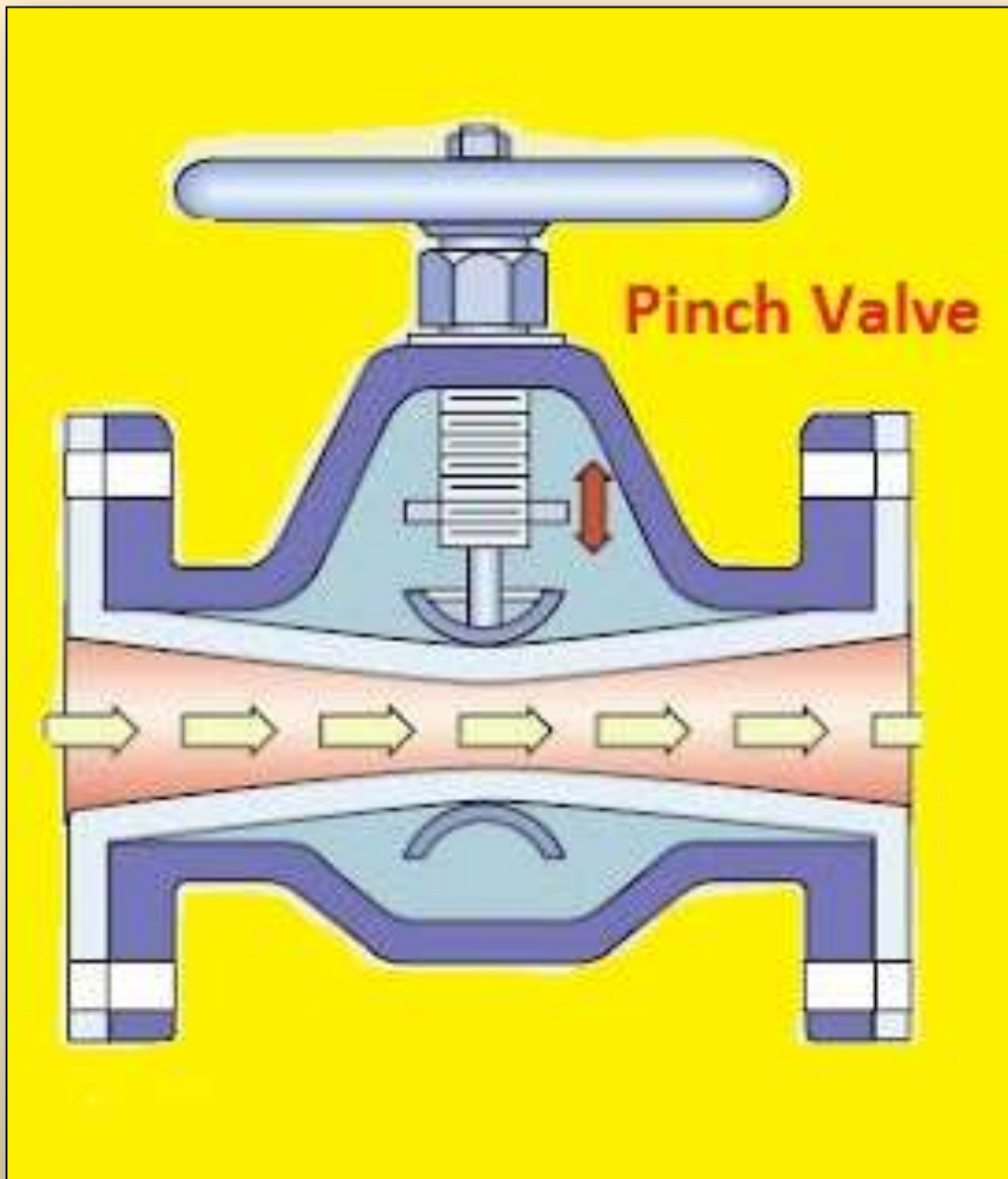
Background on the Donated Human Microbes

- 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*

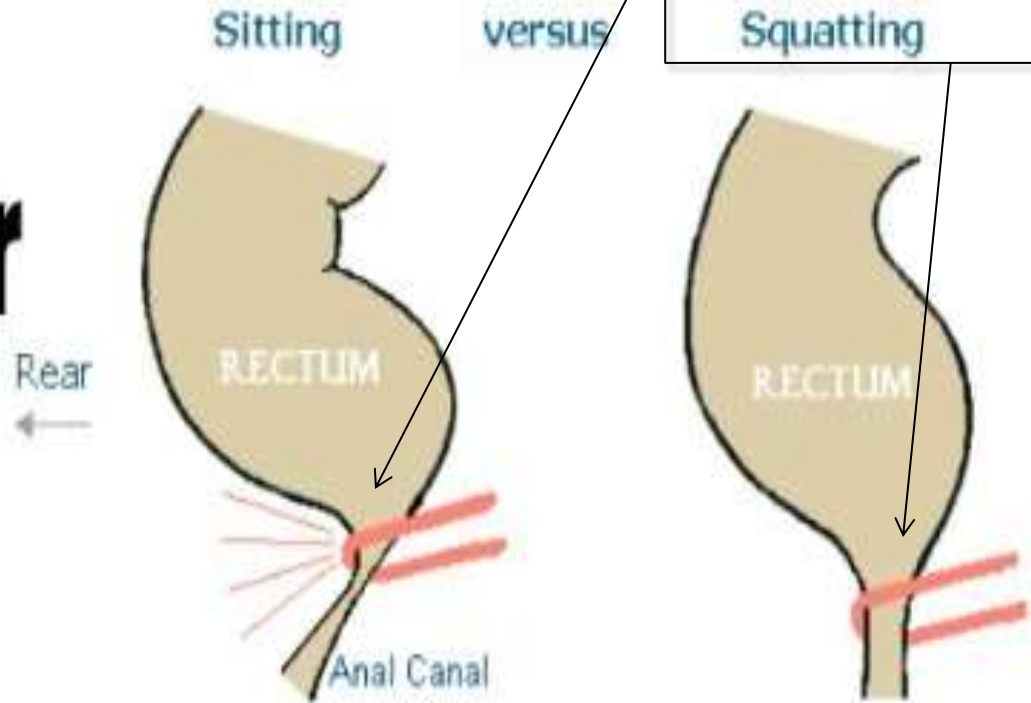


Pinch Valve and Pooping

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

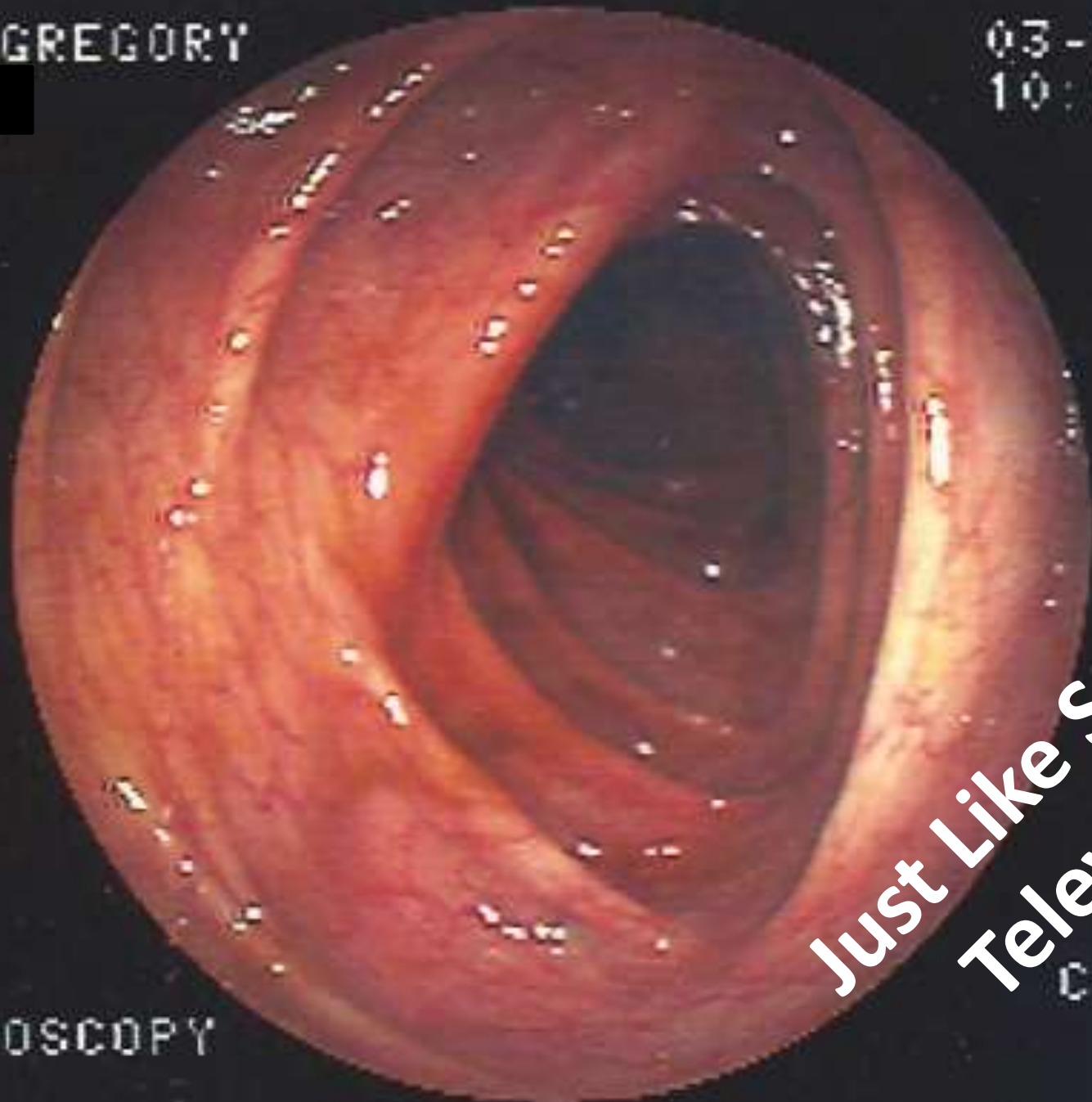
SEWER	Human
<p>Sanitary Sewer System</p>	<p>One Pipe - Various Jobs</p> <p>Esophagus - transporting food/liquid to Stomach</p> <p>Stomach - Prep food for digestion</p> <p>Small Intestine - Absorb nutrients</p> <p>Colon - Dewater waste, produce fermented products recycle water/electrolytes</p> <p>Total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

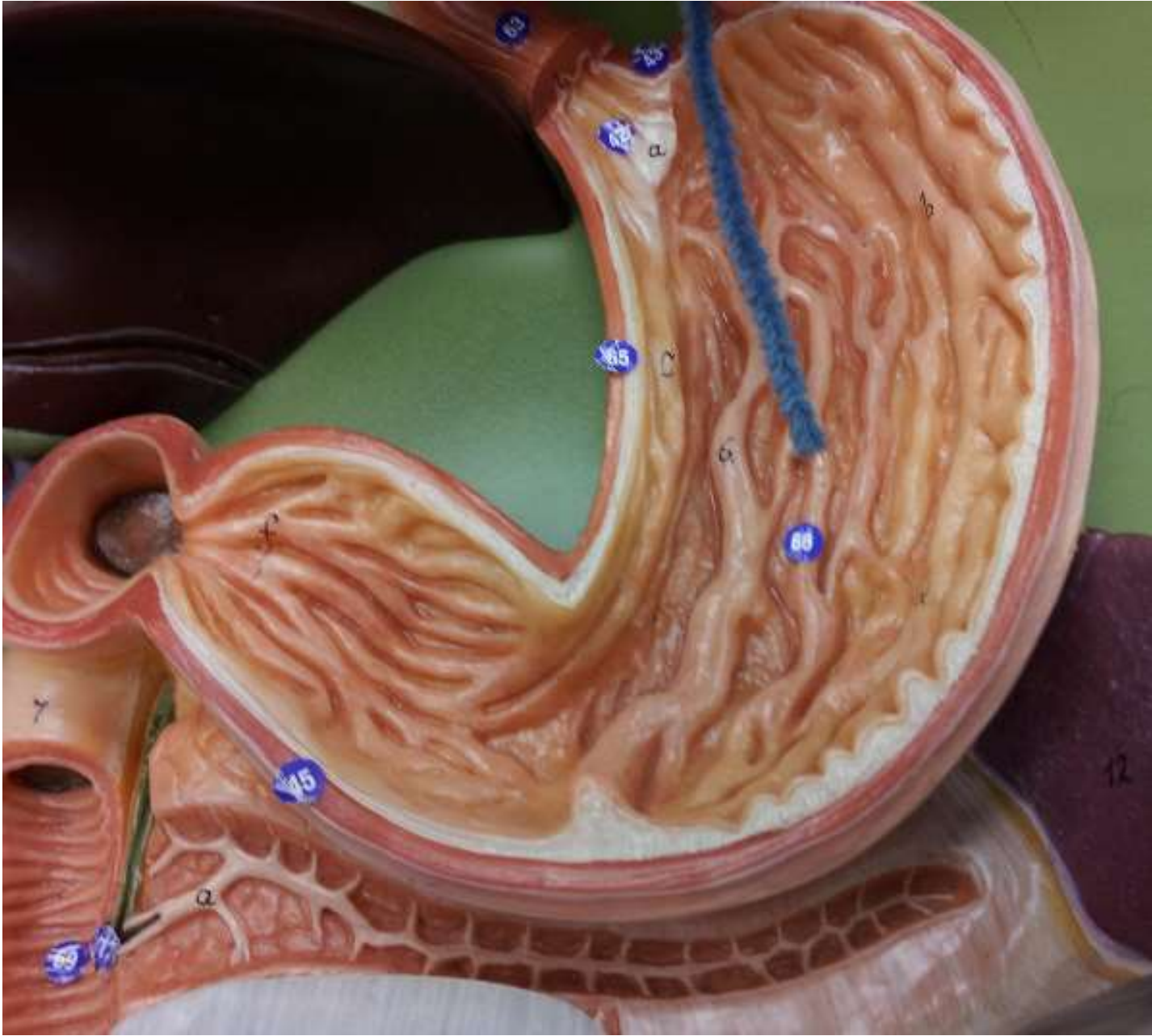


Just Like Sewer
Televising

M/38
COLONOSCOPY

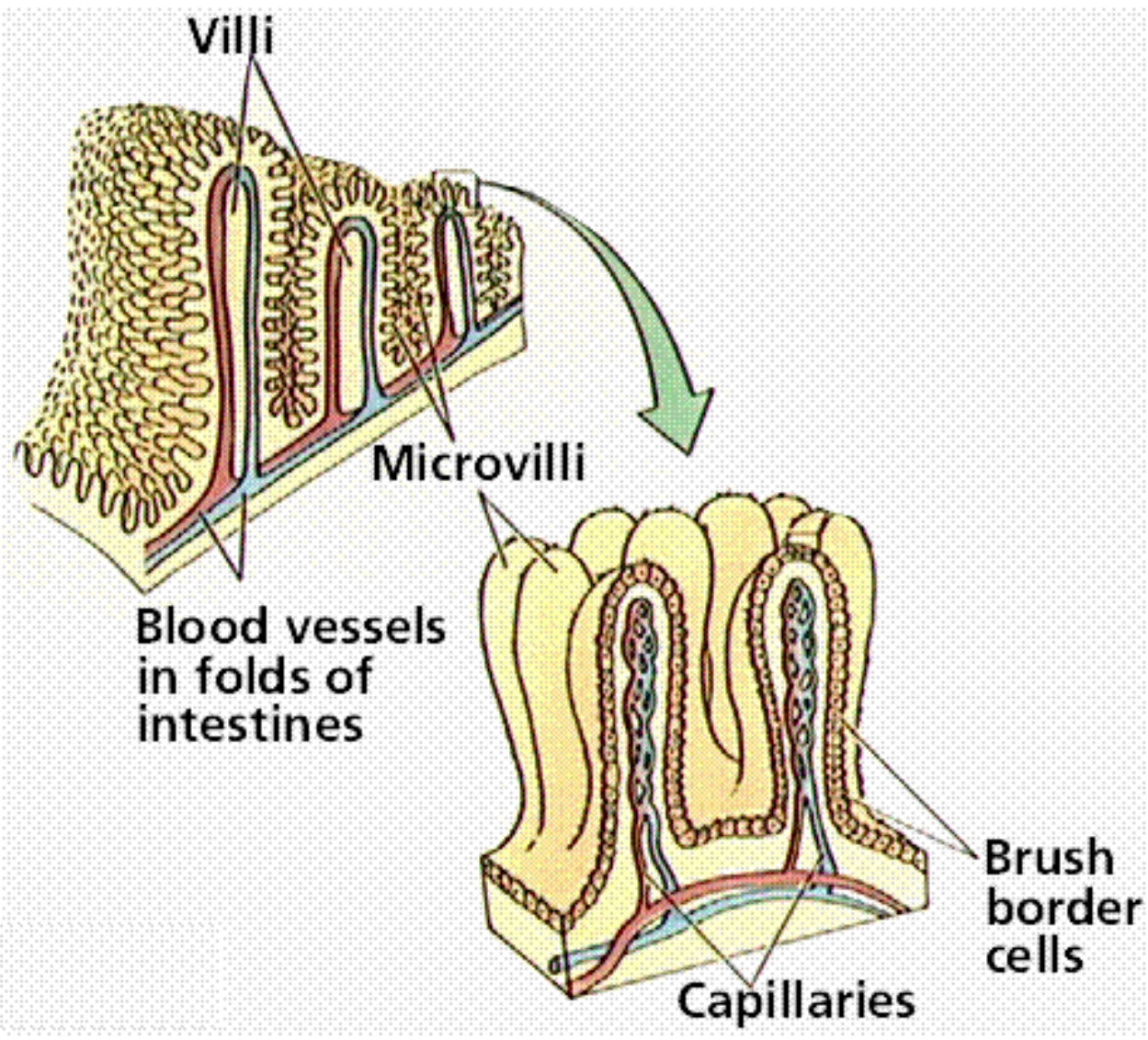
CRAHER
SFMC

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



Stomach

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



Small Intestine Villi & Microvilli

WWTP	Human
<p>Sludge Treatment, Stabilization and Dewatering</p>	<p>Colon - about 3 feet long</p> <ol style="list-style-type: none">1) Recovers water/electrolyte2) form/make feces3) ferment indigestible food <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>HRT 4 to 72 hours (3 days)</p>

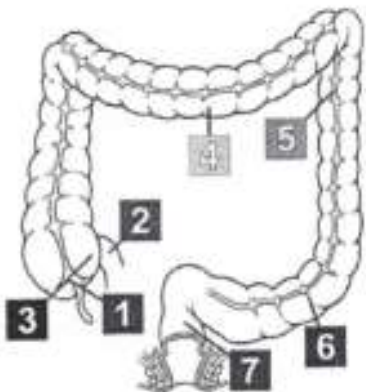


MRN:
Patient Name:
Date of Birth:

Gregory Paul

Procedure Date: 10/31/2014 9:31 AM
Age: 60
Gender: Male

Images:



The Colon



1 Appendiceal Orifice



2 Terminal Ileum



3



4 Transverse Colon



5 Descending Colon



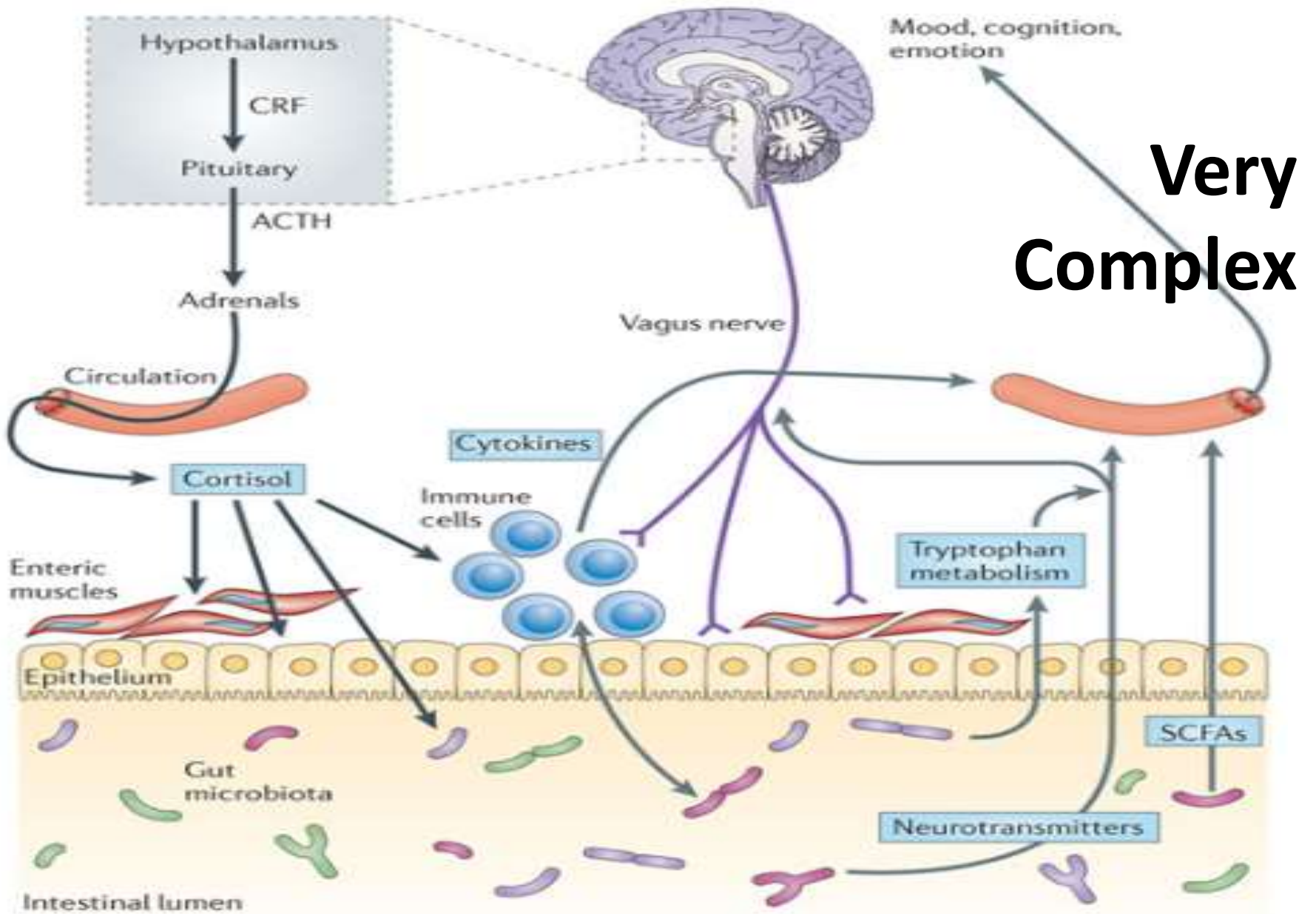
6 Sigmoid Colon



7 Rectum

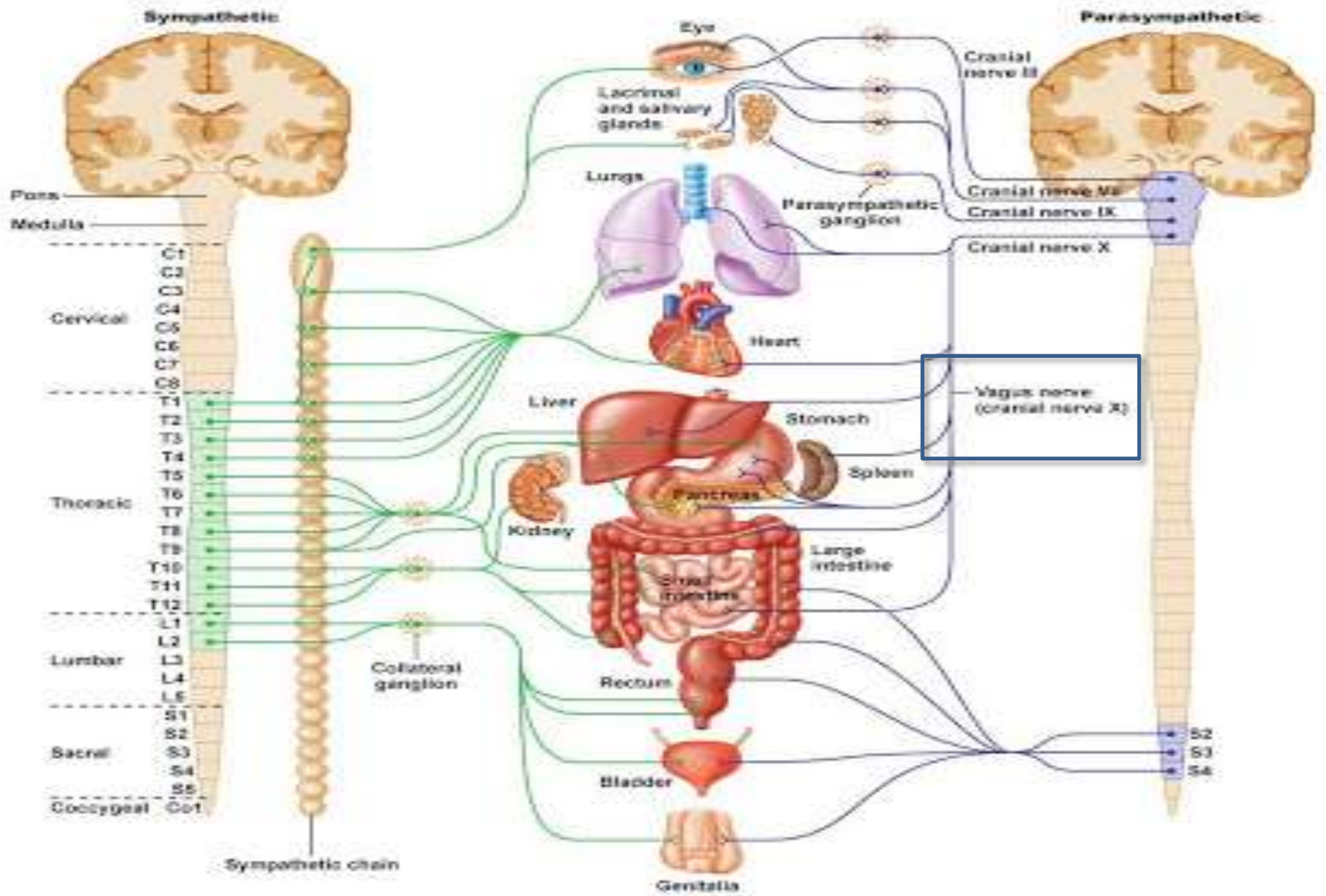
Again from the family photo album
JUST Like Televising Sewers

WWTP	Human
Disinfection	<p>Immune System - "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." - HealthPrep.com</p> <p>"Is a complex system of cellular and molecular components whose <u>primary function</u> is distinguishing self from nonself and defense against foreign organisms or substances." The FreeDictionary.com</p>

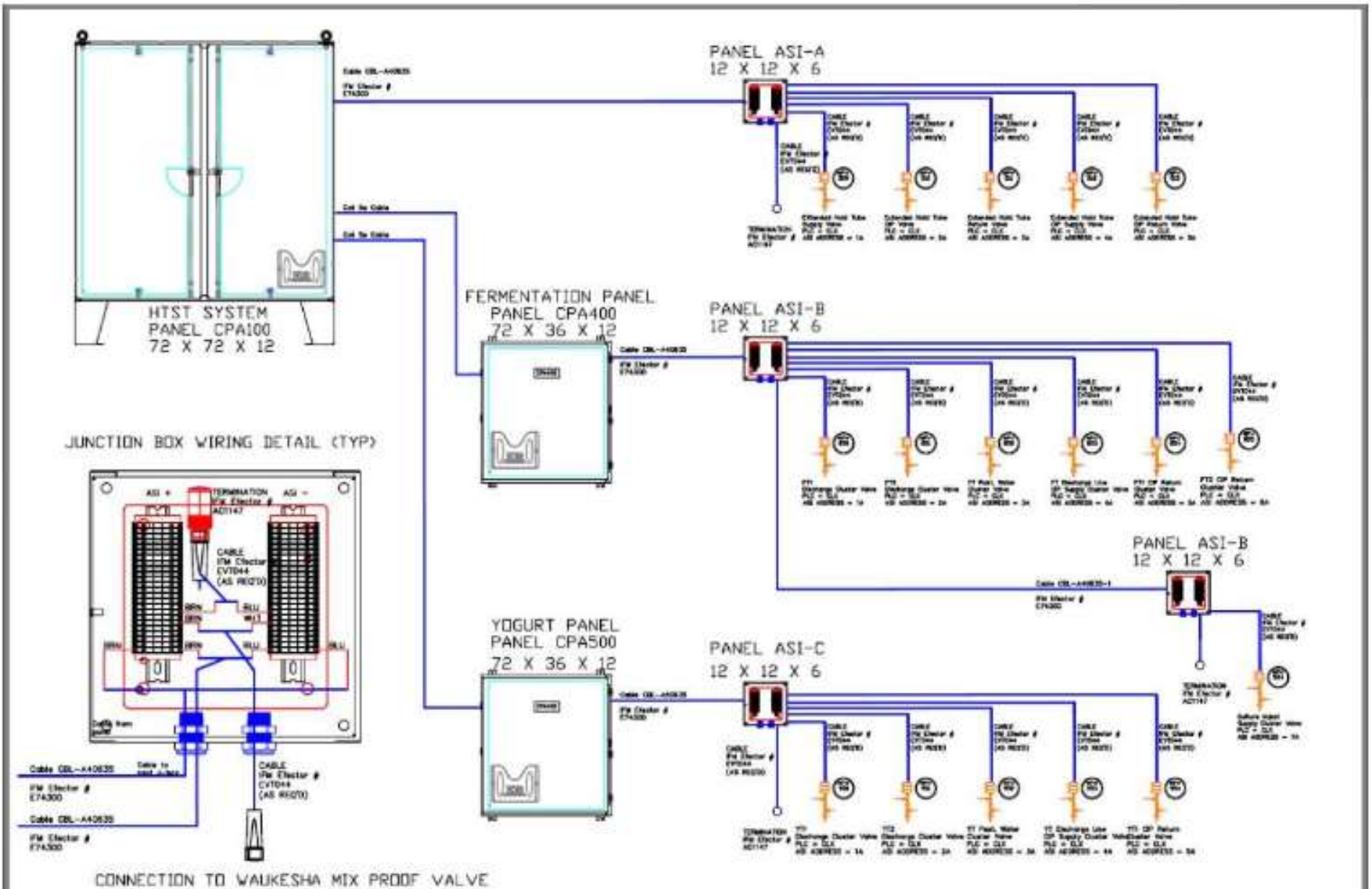



**Very
Complex**

WWTP	Human
<p>SCADA including PLCs, HMIs, Computers and Sensors and Controls</p>	<p>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</p>



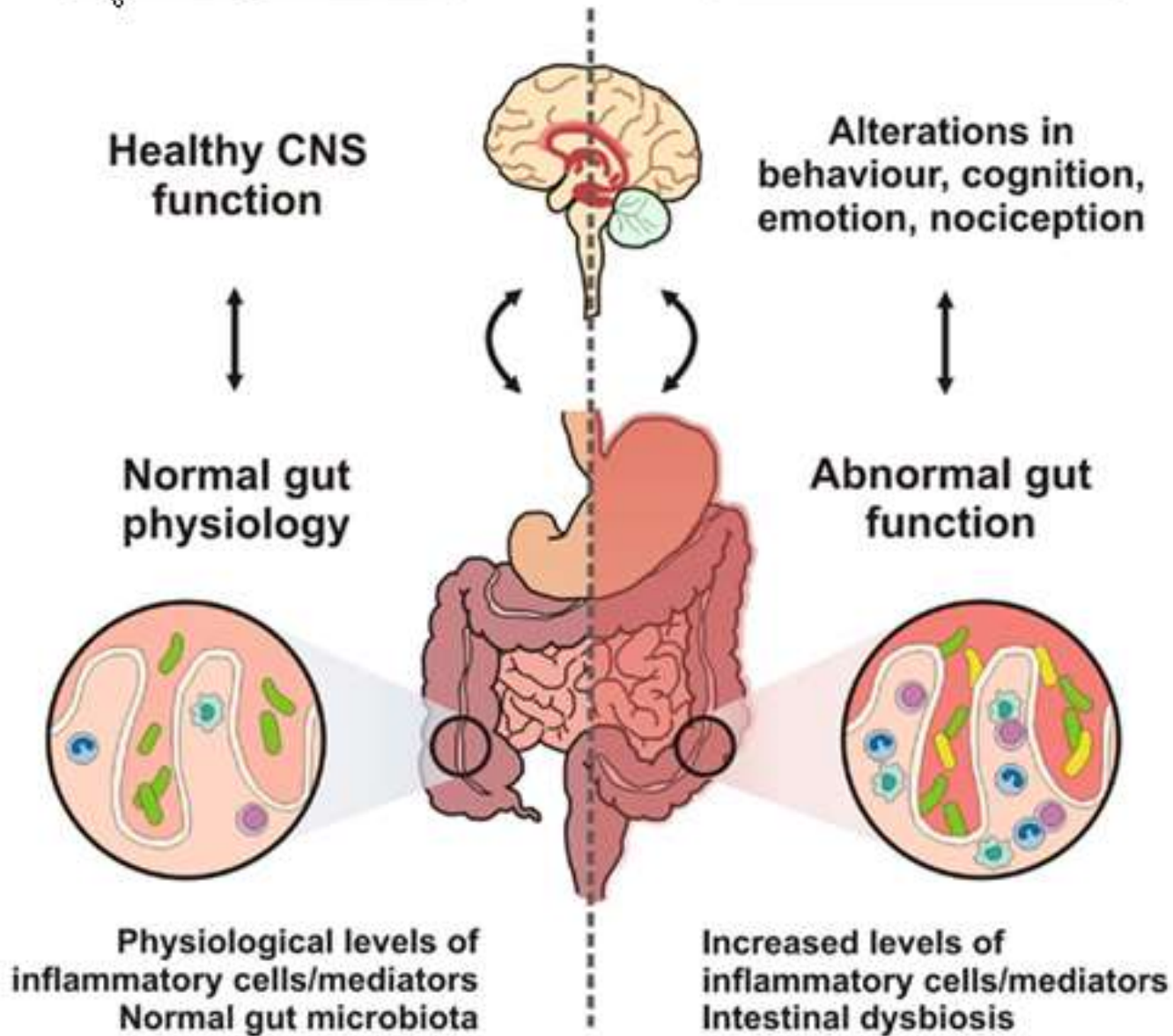
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ACME CHEESE Biscoe, NC		Number of Sites:	3	Start Date:	3	Drawn By:	SPM		Drawing Number:	ASI-NET
ASI NETWORK CONNECTION Network Connection		Project Number:	AT2362	File Name:	ASI-NET.dwg	Creation Date:	09/29/2014		Revision:	A

Healthy status

Stress/disease



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

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

GP

*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

BRISTOL STOOL CHART

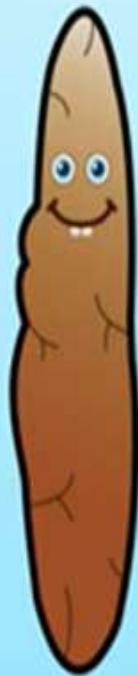
TYPE 1



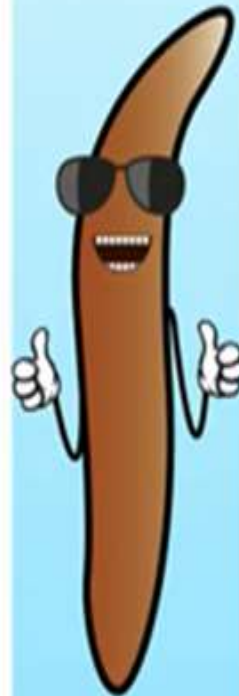
TYPE 2



TYPE 3



TYPE 4



TYPE 5



TYPE 6



TYPE 7



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

Bioreactor Type	Low HRT	Design (Normal) HRT	High HRT
Anaerobic Digester	Poor treatment doesn't meet vector attraction limits, sludge smells sour	Meet vector attraction limits, sludge smells	Not many gains in treatment over and above Design, complete treatment – maximum gas production
Activated Sludge	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
Human	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

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 $\frac{1}{2}$ to $\frac{3}{4}$ of plate, the rest of plate is whole fruit, “Good” fats and**

Bugs Relying on Bugs(And/or Human)

- **Anaerobic Digester – bugs produce VFAs → 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**

Jump Starting Populations AF

- 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**

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 to Advance the
Education and Training
of Water and Wastewater
Professionals

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
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METAGENOMICS • DATA SCIENCE • BIOBANKING

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**

Slime Bulking

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

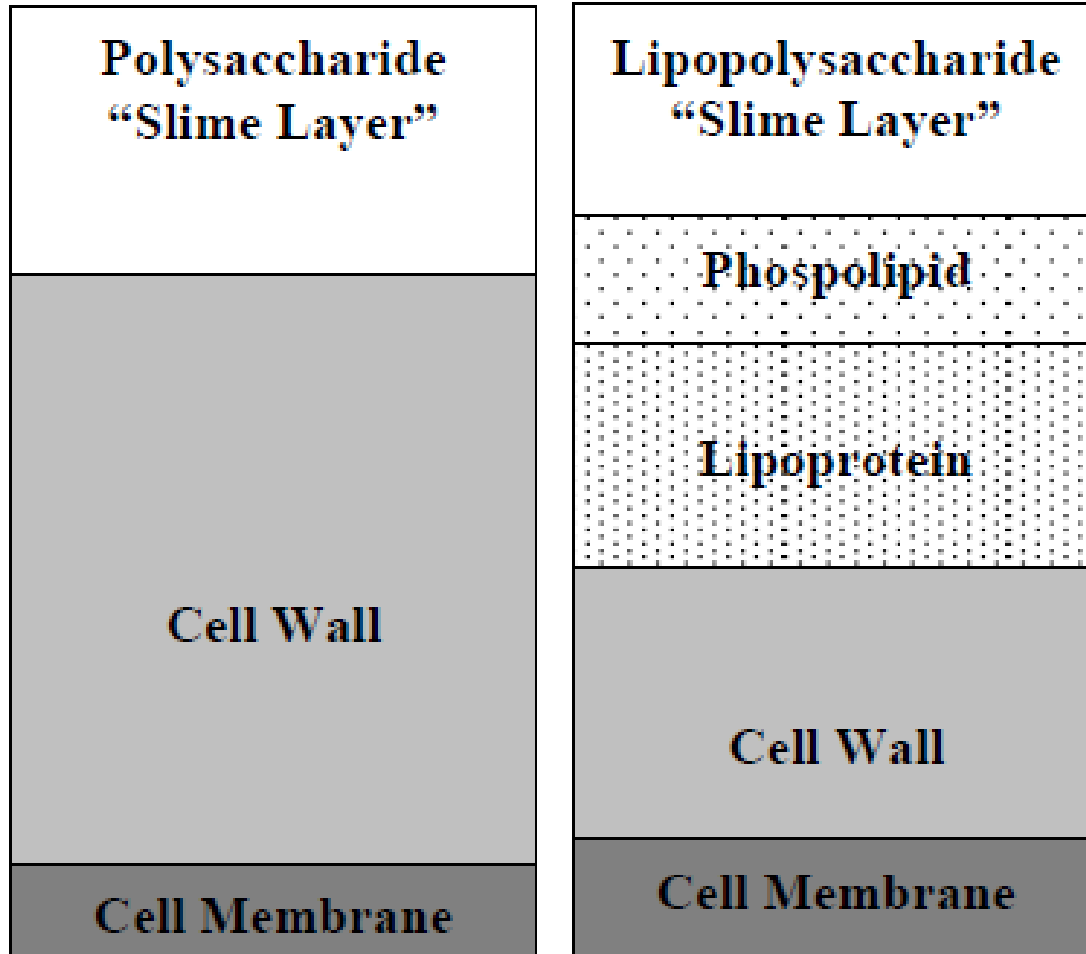
Tony Glymph-Martin

- 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 Activated Sludge

Gram (+)

Gram (-)



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?

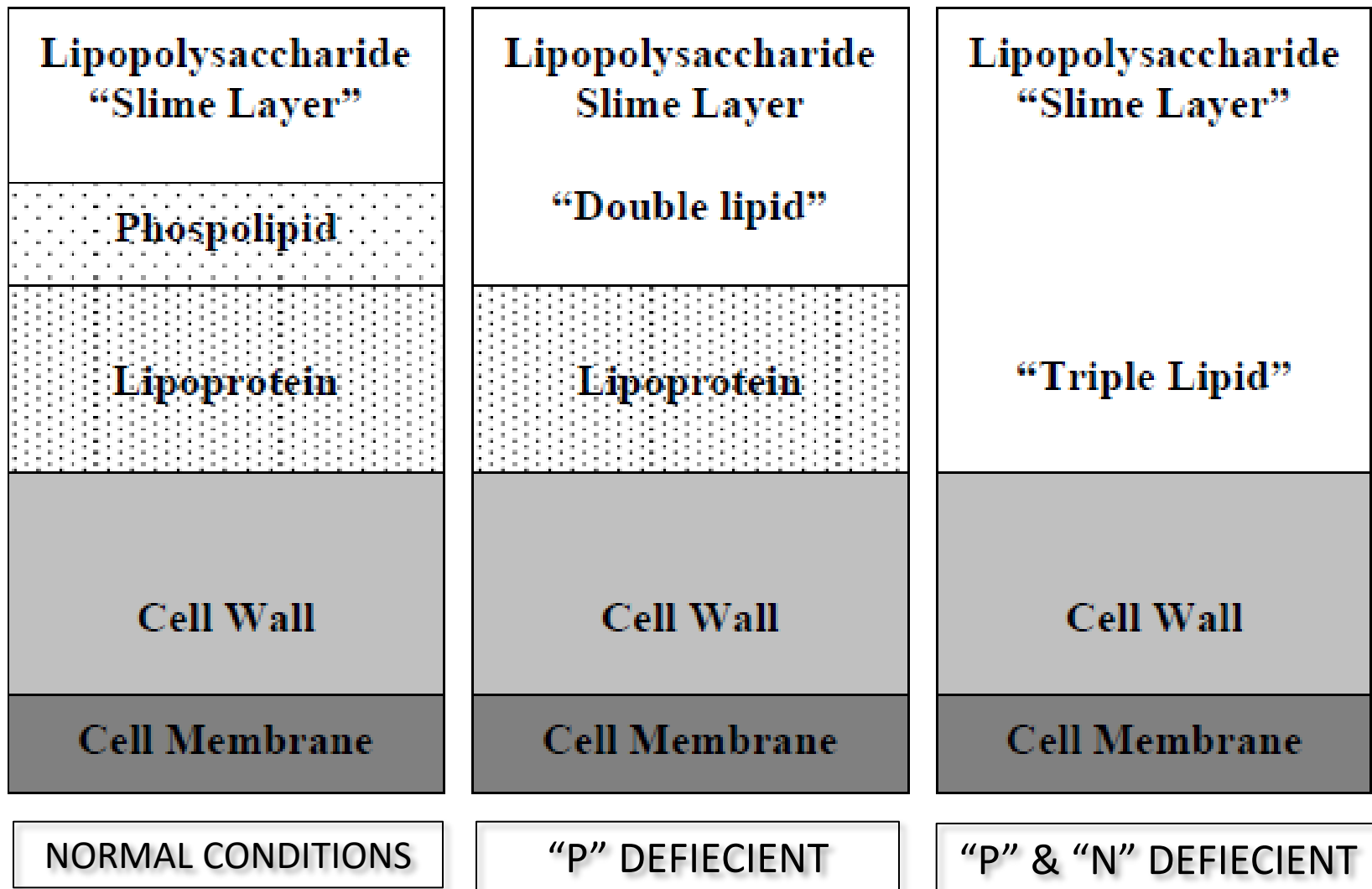
Causes inflammation in any place within the body

NORMAL CONDITIONS

LPS in Activated Sludge

(WWTP BIG Gut)

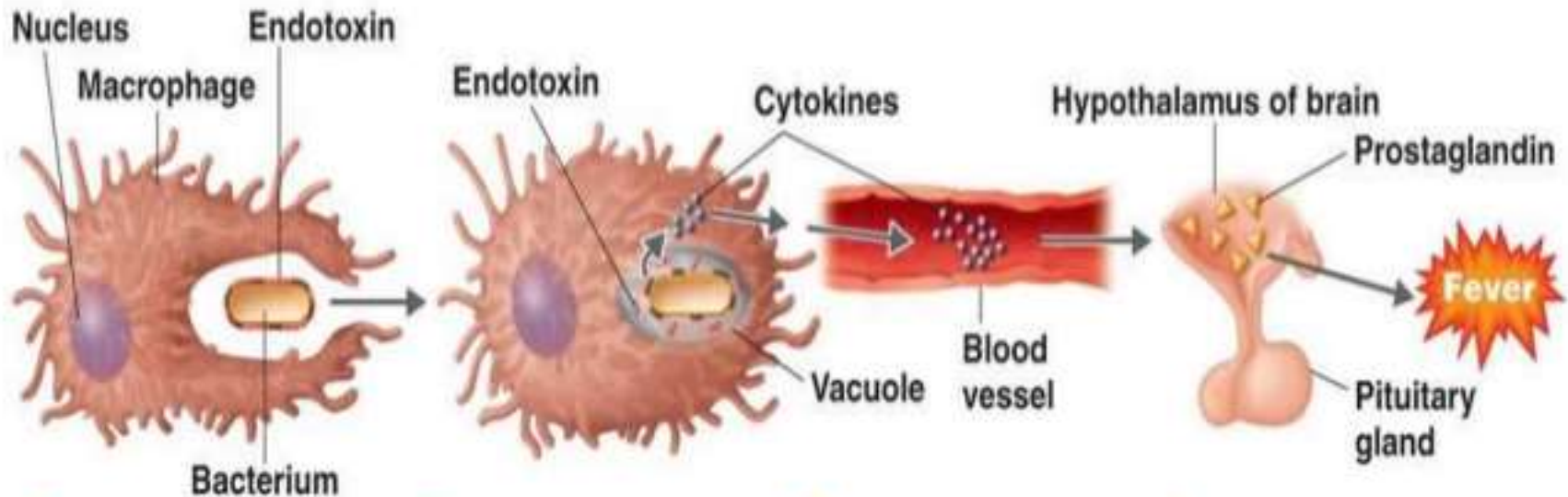
Gram (-)



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.

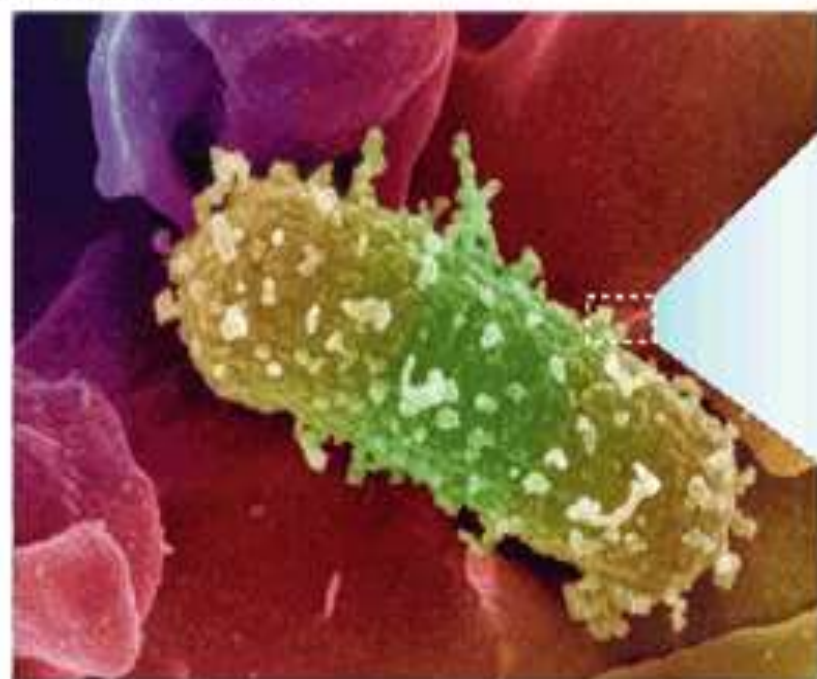
2 The bacterium is degraded in a vacuole, releasing endotoxins that induce the macrophage to produce cytokines IL-1 and TNF- α .

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

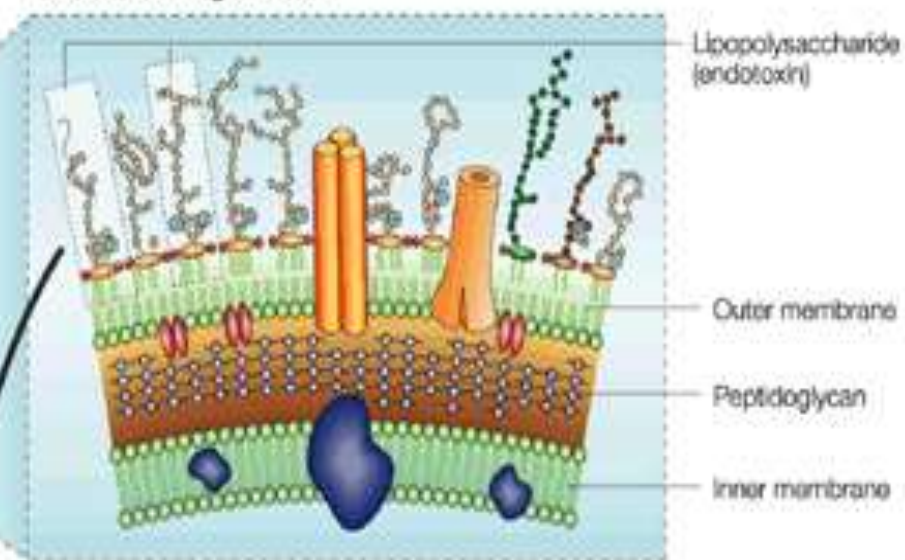
4 The cytokines induce the hypothalamus to produce prostaglandins, which reset the body's "thermostat" to a higher temperature, producing fever.

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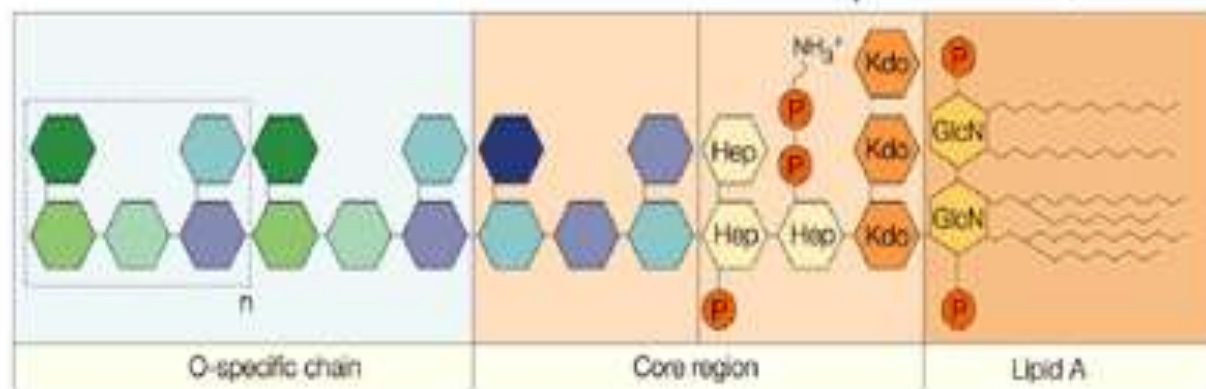
a Bacterial cell (*E. coli*)



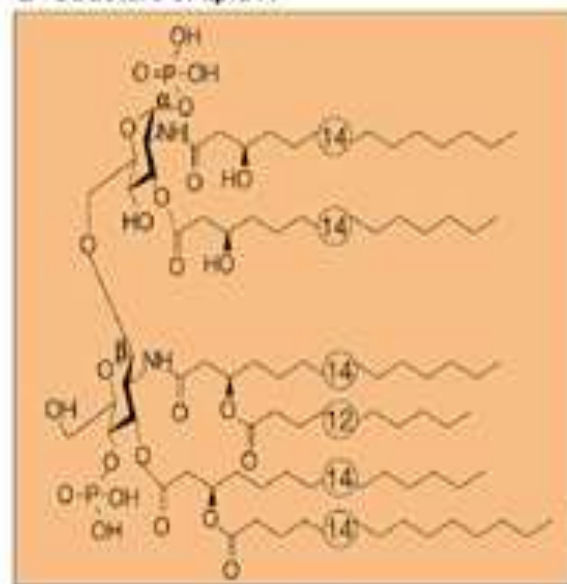
b Cell-wall organization



c Architecture of lipopolysaccharide



d Structure of lipid A



On Low Nutrient & Dietary Fiber Diets

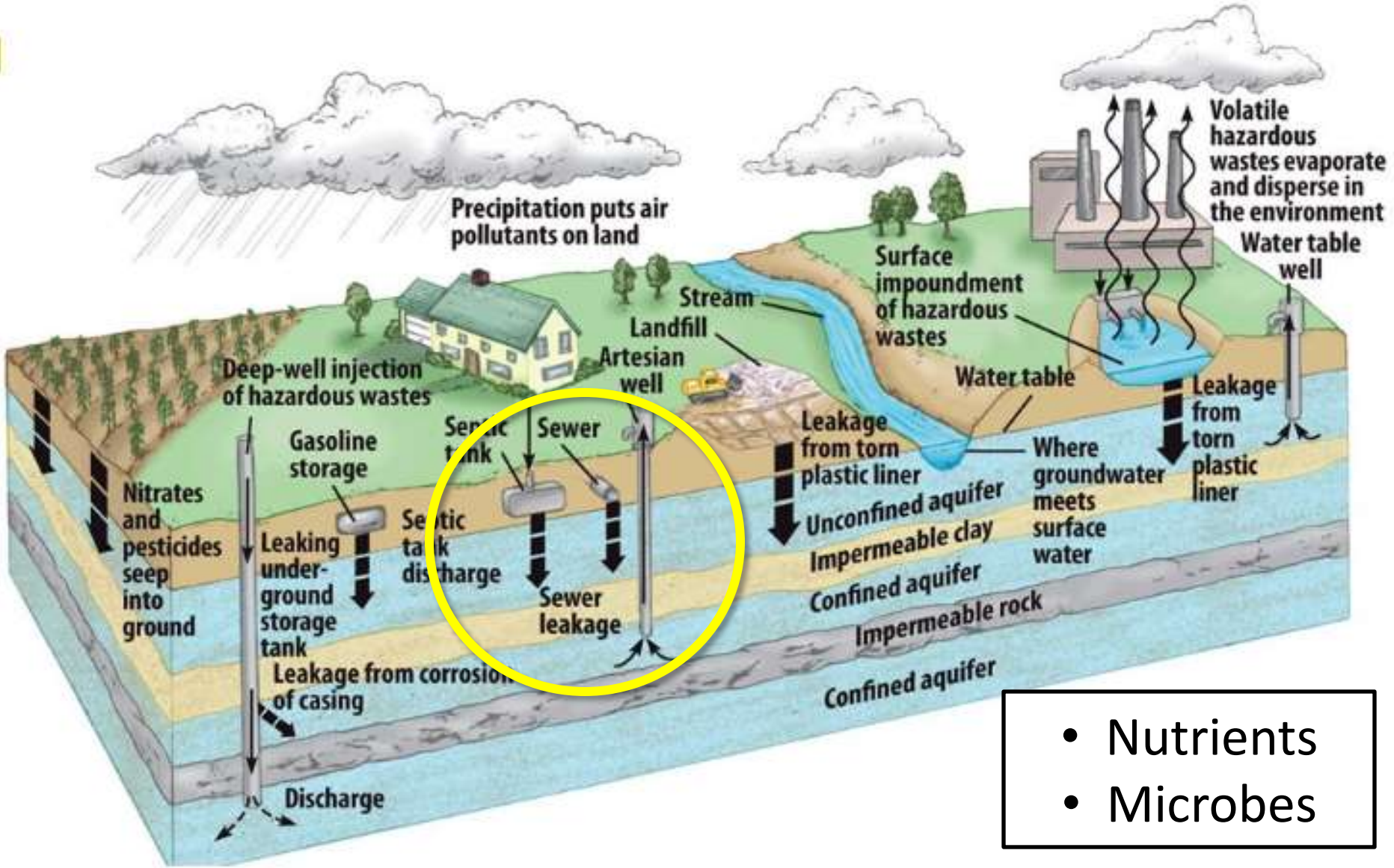
Microbes Starve in Colon

- 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

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**

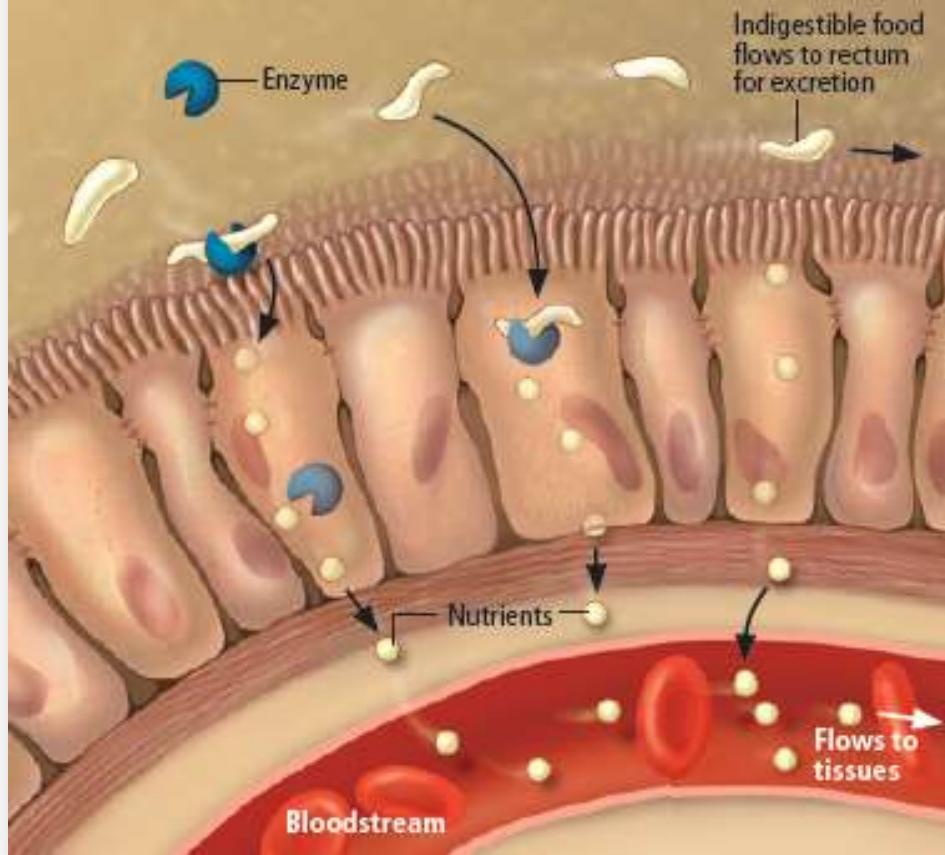
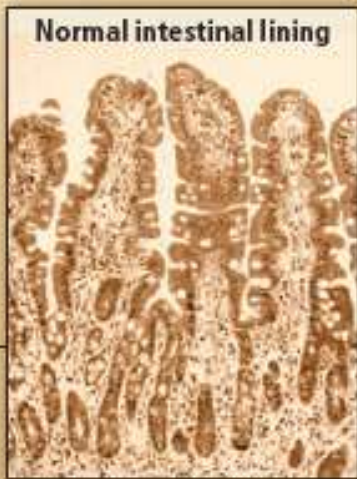
Groundwater Pollution



- Nutrients
- Microbes



Waste water flow



Surprises from Celiac Disease

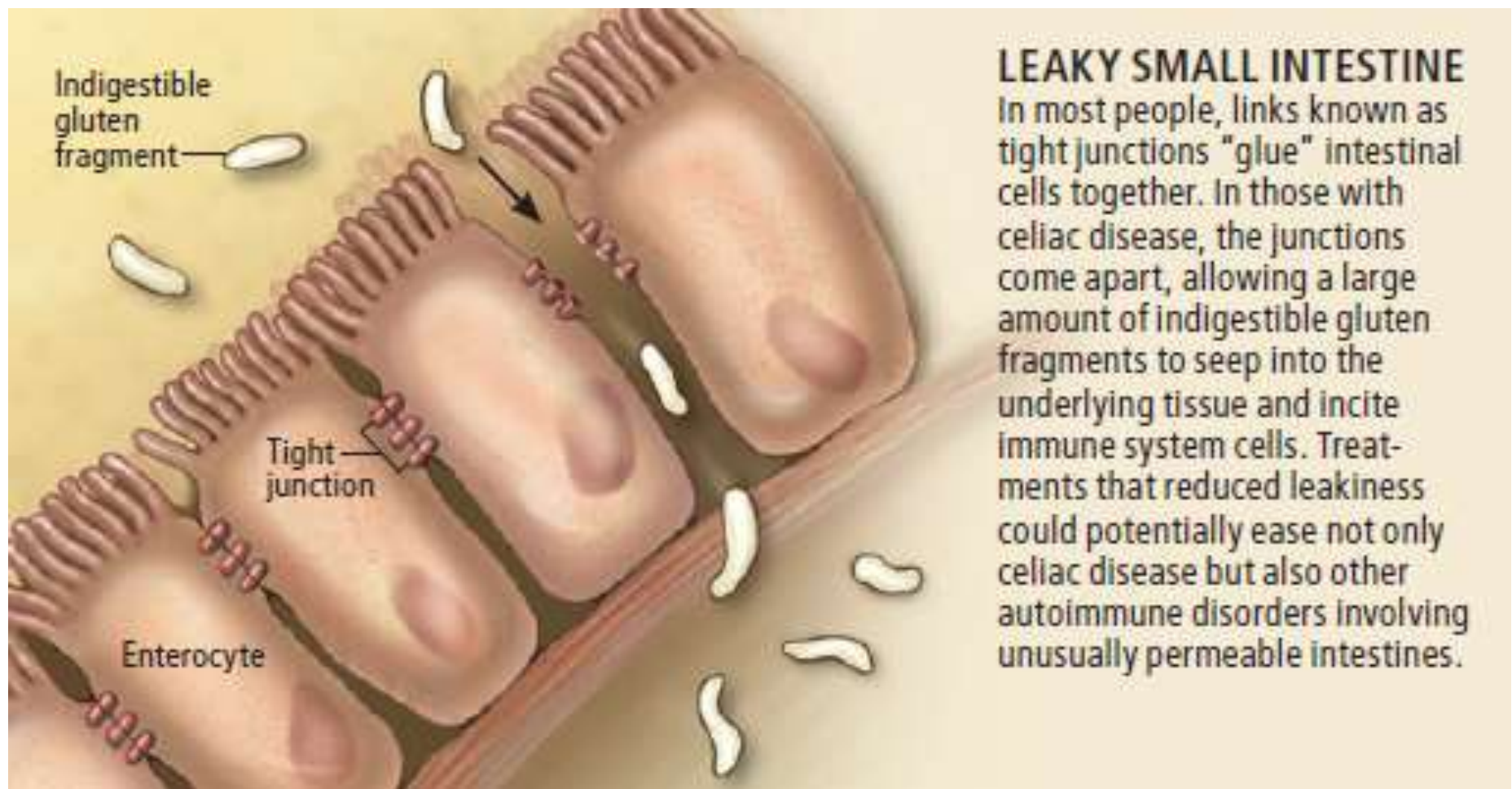
Study of a potentially fatal food-triggered disease has uncovered a process that may contribute to many autoimmune disorders

By Alessio Fasano

Sept 2009

OLD NOW

OUT OF SIGHT OUT OF MIND !!!



Surprises from Celiac Disease

By Alessio Fasano

Zonulin

- 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



MASSACHUSETTS
GENERAL HOSPITAL

Conditions &
Treatments

Centers &
Departments

Education &
Training



[Find a Doctor](#)

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

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 s 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

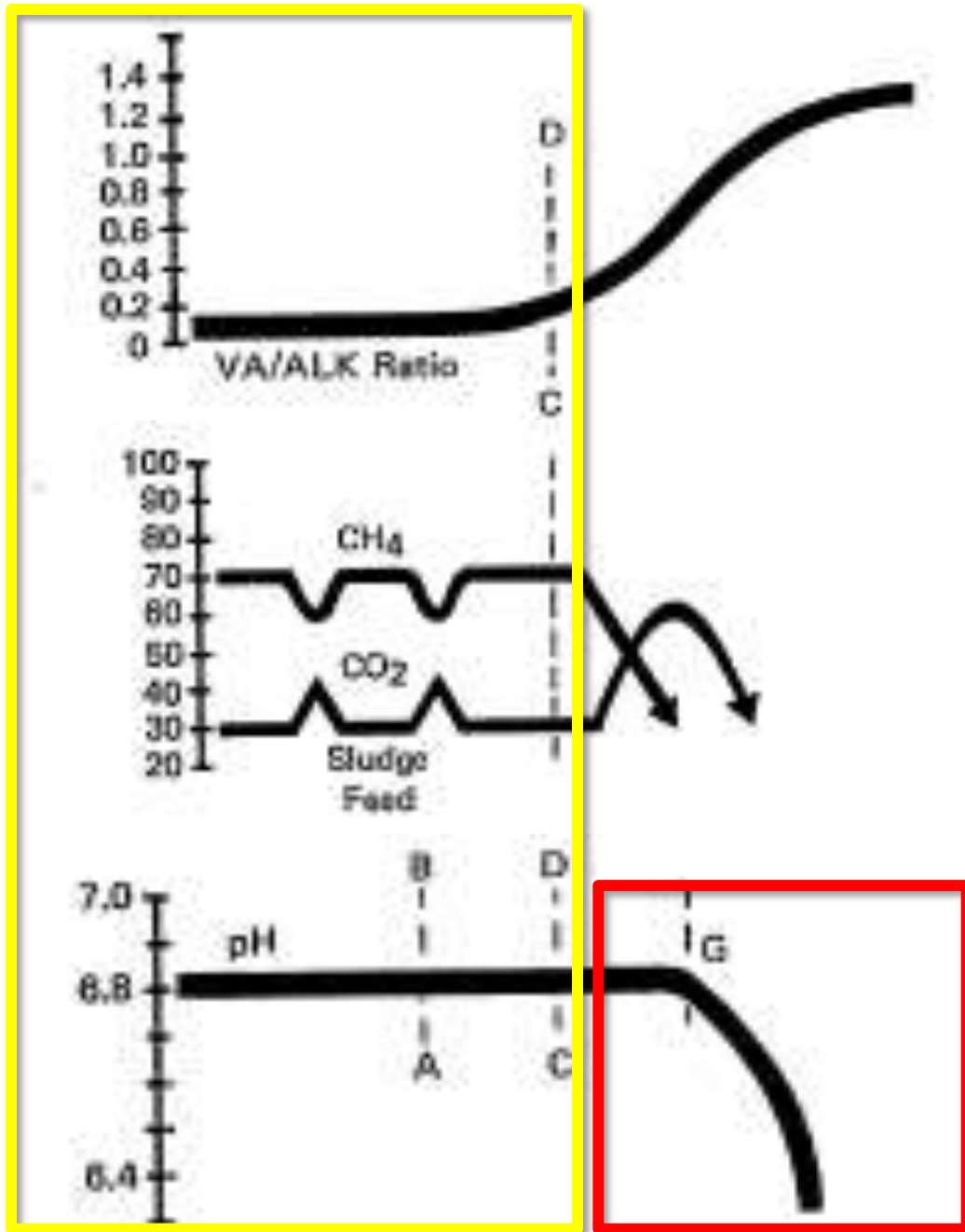
Sour Anaerobic Digester

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

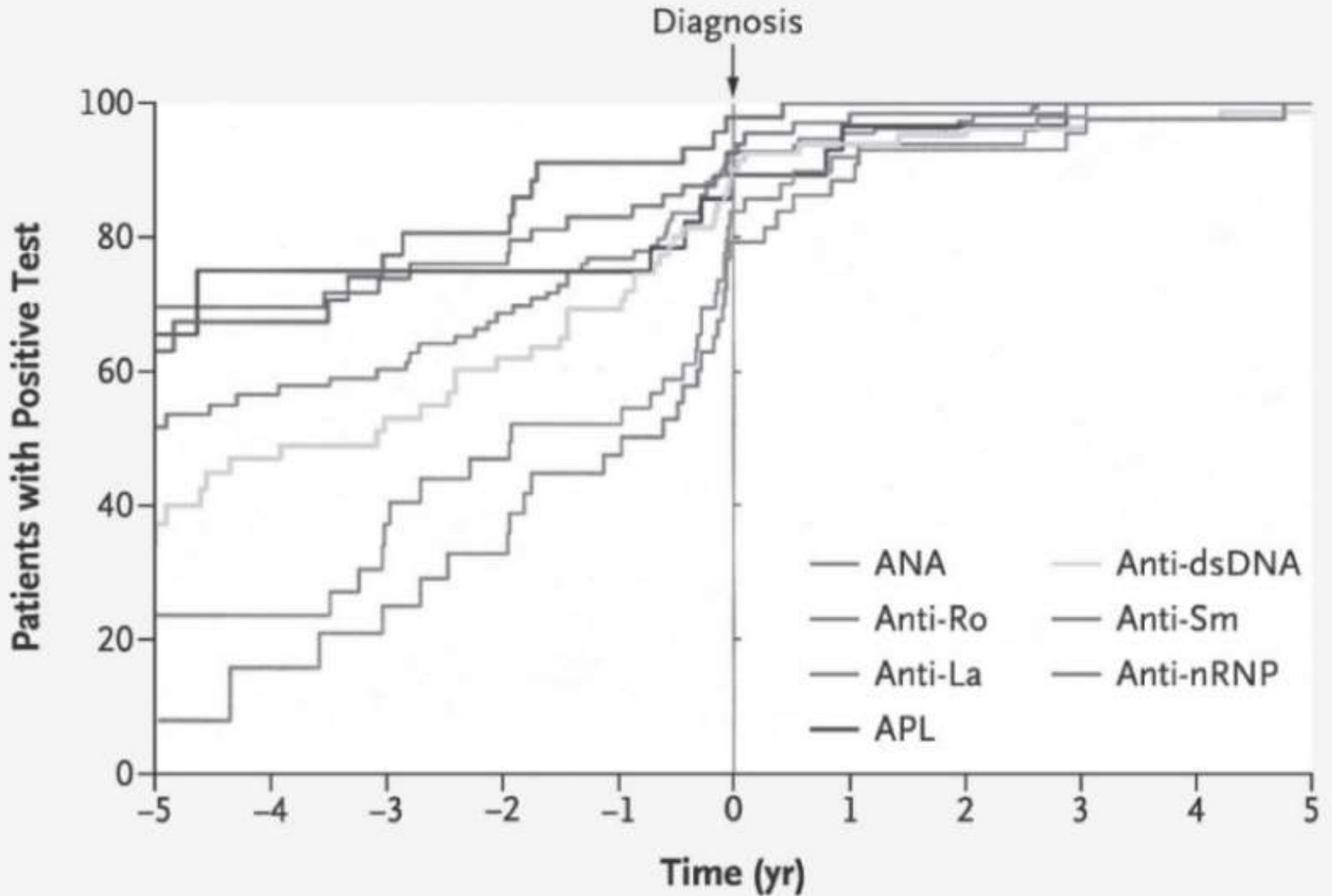
SPECTRUM OF AUTOIMMUNITY

- 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-S

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 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.