Learning objectives

Lecture Objectives - At the completion of this program, participants will know/be able to:

1. Understand the differences between culture based and culture-independent approaches for assessing human microbes

2. Describe three culture independent, 'omic based approaches for profiling a clinical sample, and learn about resources available at UC Irvine

3. Critically review near-term applications of microbiome research (i.e. fecal transplant for Clostridia difficile infection, and Bifidobacter colonization in infants)

4. Analyze current issues impacting the potential for phage therapy to become a viable alternative to antibiotics

5. Apply knowledge obtained from the past 10 years of research, including the Human Microbiome Project to future infection treatment and potential reductions in autoimmune disease, allergy and cancer

Katrine Whiteson
Andrew Oliver and Stephen Wandro
University of California, Irvine
OLLI Oct 16, 2017
http://faculty.sites.uci.edu/whitesonlab/

New website: microbiome.uci.edu
Human associated microbial communities in health and disease

Katrine Whiteson
University of California, Irvine
OLLI Oct 16, 2017
The Effect of Infections on Susceptibility to Autoimmune and Allergic Diseases

Jean-François Bach, M.D., D.Sc.


Microbial exposure in buildings

Mechanically ventilated air dominated by human associated microbes

Sources of Air:
- Mechanical
- Open Window
- Outdoor

Community Composition 1
Community Composition 2

An average American spends 93% of their life indoors - EPA

https://www.ted.com/talks/jessica_green_are_we_filtering_the_wrong_microbes#t-201849
M122 Lecture 12 Microbiome
Whiteson Spr2017
Pre-treatment microbial *Prevotella*-to-*Bacteroides* ratio, determines body fat loss success during a 6-month randomized controlled diet intervention

OPEN

M F Hjorth¹, H M Roager², T M Larsen¹, S K Poulsen¹,³, T R Licht², M I Bahl², Y Zohar⁴ and A Astrup¹

Based on the abundance of specific bacterial genera, the human gut microbiota can be divided into two relatively stable groups that might play a role in personalized nutrition. We studied these simplified enterotypes as prognostic markers for successful body fat loss on two different diets. A total of 62 participants with increased waist circumference were randomly assigned to receive an *ad libitum* New Nordic Diet (NND) high in fiber/wholegrain or an Average Danish Diet (ADD) for 26 weeks. Participants were grouped into two discrete enterotypes by their relative abundance of *Prevotella* spp. divided by *Bacteroides* spp. (*P/B* ratio) obtained by quantitative PCR analysis. Modifications of dietary effects of pre-treatment *P/B* group were examined by linear mixed models. Among individuals with high *P/B* the NND resulted in a 3.15 kg (95%CI 1.55;4.76, *P*<0.001) larger body fat loss compared to ADD whereas no differences was observed among individuals with low *P/B* (0.88 kg [95% CI −0.61;2.37, *P*=0.25]). Consequently, a 2.27 kg (95%CI 0.09;4.45, *P*=0.041) difference in responsiveness to the diets were found between the two groups. In summary, subjects with high *P/B*-ratio appeared more susceptible to lose body fat on diets high in fiber and wholegrain than subjects with a low *P/B*-ratio.
YOUR AMERICAN GUT SAMPLE

MICHAEL POLLAN

What’s in your American Gut sample?

- **Your most abundant microbes:**
  - Taxonomy: Genus *Prevotella*
    - Sample: 24.9%
  - Taxonomy: Family Ruminococcaceae
    - Sample: 13.4%
  - Taxonomy: Family Lachnospiraceae
    - Sample: 10.1%
  - Taxonomy: Genus *Bacteroides*
    - Sample: 10.0%

- **Your most enriched microbes:**
  - Taxonomy: Genus *Clostridium*
    - Sample: 2.5%
      - Population: 0.3%
      - Fold: 7x
  - Taxonomy: Genus *Finegoldia*
    - Sample: 0.7%
      - Population: 0.0%
      - Fold: 17x
  - Taxonomy: Genus *Prevotella*
    - Sample: 24.9%
      - Population: 2.6%
      - Fold: 9x
  - Taxonomy: Genus *Collinsella*
    - Sample: 0.9%
      - Population: 0.1%
      - Fold: 8x

This sample included the following rare taxa: Genus *Varibaculum*, Genus *Neisseria*, Genus *Campylobacter*, Order ML615J-28

How do your gut microbes compare to others?

- **Different body sites**
- **Different ages and populations**
- **The American Gut population**

https://thequantifiedbody.net/category/biomarkers/microbiome/
Oral Cavity

The oral cavity contains dense and diverse microbial communities. They are mostly anaerobes, good at fermenting and tolerating low pH. Acid from fermentation causes cavities. Microbial communities in gingivitis look different. Correlations between dental health and heart disease and also pre-term birth.

Fig. 2. Corncob structures formed by *Corynebacterium* and cocci in plaque. *Corynebacterium* cells (magenta) are visible as long filaments, with cocci (green) bound to the tips of the filaments. Partially disrupted plaque was dissolved in MilliQ water and imaged by CLSM.

Biogeography of a human oral microbiome at the micron scale

Jessica L. Mark Welch, Blair J. Rossetti, Christopher W. Rieken, Floyd E. Dewhirst, and Gary G. Borisy
No man is an island

...but his teeth may be an archipelago...

- unique communities on individual teeth!
- lateral symmetry in mouth

Clara Davis Long & David Relman
Stanford University, CA
What does a healthy oral microbial community look like?
- 5 healthy people in Geneva
- 3 saliva collection timepoints each

DNA extraction, analysis of taxonomy and community composition

“Study of Inter- and Intra-individual variations in the salivary microbiota” BMC Genomics (2010) 11:523
Family Project

• **96 saliva samples**
  - 4 families of 4 (16 people)
  - 3 days in April
  - 3 days in June
  - $16 \times 6 = 96$ total

<table>
<thead>
<tr>
<th># raw seqs</th>
<th>495814</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good seqs</td>
<td>343904</td>
</tr>
</tbody>
</table>

Saliva
↓
DNA extraction
↓
PCR (16S primer and barcode)
↓
454 Sequencing
↓
Quality control & barcode identification
↓
Alpha and beta diversity metrics

Whiteson et al unpublished
Families share oral microbes

**ANOSIM**: a permutation based test of the null hypothesis that within-group samples are not more similar than between group samples.

ANOSIM between Families
R: .491    p: 0.1%

Whiteson et al unpublished
Manipulate the Microbiome

• Probiotics and prebiotics
  – Shape the composition and activity of microbes by providing nutrients in probiotics

• Fecal transplant
  – Replenish gut microbiome after antibiotics

• Phage therapy
  – Targeted bacterial killing
Sepsis reduced by 40% with probiotics

A randomized synbiotic trial to prevent sepsis among infants in rural India

Pinaki Panigrahi1,2, Sailajanandan Parida3, Nimai C. Nanda4, Radhanath Satpathy5, Lingaraj Pradhan6, Dinesh S. Chandel7, Lorena Baccaglini1, Arjit Mohapatra3, Subhranshu S. Mohapatra5, Pravas R. Misra5, Rama Chaudhry8, Hegang H. Chen9, Judith A. Johnson10, J. Glenn Morris Jr10, Nigel Paneth11 & Ira H. Gewolb12

Sepsis in early infancy results in one million annual deaths worldwide, most of them in developing countries. No efficient means of prevention is currently available. Here we report on a randomized, double-blind, placebo-controlled trial of an oral synbiotic preparation (Lactobacillus plantarum plus fructooligosaccharide) in rural Indian newborns. We enrolled 4,556 infants that were at least 2,000 g at birth, at least 35 weeks of gestation, and with no signs of sepsis or other morbidity, and monitored them for 60 days. We show a significant reduction in the primary outcome (combination of sepsis and death) in the treatment arm (risk ratio 0.60, 95% confidence interval 0.48–0.74), with few deaths (4 placebo, 6 synbiotic). Significant reductions were also observed for culture-positive and culture-negative sepsis and lower respiratory tract infections. These findings suggest that a large proportion of neonatal sepsis in developing countries could be effectively prevented using a synbiotic containing L. plantarum ATCC-202195.

At Last, a Big, Successful Trial of Probiotics

A large Indian study of 4,500 newborn babies found that the right microbes can prevent a life-threatening condition called sepsis.
Babies need both human milk oligosaccharides and exposure to *Bifidobacteria* containing the genes that encode enzymes to break down HMOs to have a healthy bifidobacteria containing gut microbiota in early life.
For tens of thousands of years human babies have been vaginally delivered and nourished by human breast milk. Ironically, modern birthing, nutrition, and hygiene practices in the US and other western societies have resulted in infants with higher rates of respiratory, GI disorders, and hyper-allergenic responses than corresponding infants in many emerging nations. This has now been correlated to the type and diversity of the microflora in the baby’s GI tract that is originally obtained from direct contact with the mother.

It is now clearly established that a healthy gut microbiota is paramount to the general health of individuals. Establishing the health of the gut in infants is important for the proper development of the adult gut microbiota. Evolve’s scientists have discovered a link between human milk and a specific bacteria that makes up as much as 80% of the microbiome in a healthy breast-fed babies in the first 6 months of life. Based on the team’s expertise in prebiotics, probiotics, and their interactions, Evolve is developing a proprietary and effective probiotic bacteria, activated with specific prebiotic oligosaccharides and delivery systems to provide and maintain a healthy microbiome in all infants during the first 6 months of life.

Company developing **Bifidobacteria** from UC Davis research
Premature Infant Study

**Goal:** Study microbial community assembly early in life

- 77 fecal samples from 26 infants
  - 3 necrotizing enterocolitis
  - 8 late onset sepsis
  - 15 healthy
- V3-V4 region of 16S rRNA gene sequenced
- GC-MS untargeted metabolite profiling

**NEC:**

- 0 20 21 35
- 0 1 2 17
- 0 1 12 13 14 16 16

**Septic:**

- 0 -1 8 9 10 12 13
- -6 0
- 0 0 21 43
- -24 0 1 4 11
- 0 9 10
Enterococcus highly abundant in premature infant guts

Microbial Community Assembly And Metabolite Profile Of The Gut Microbiome In Extremely Low Birthweight Infants

Stephen Wandro, Stephanie Osborne, Claudia Enriquez, Claudia Bixby, Antonio Arrieta, Katrine Whiteson
doi: https://doi.org/10.1101/125922
Goal: Study microbial community assembly early in life

We imagine a world in which children grow up with healthy microbial communities. A focus on early life during microbiome assembly is ideal, when the potential to make effective interventions to reduce disease risk is greatest.
Manipulate the Microbiome

• Probiotics and prebiotics
  – Shape the composition and activity of microbes by providing nutrients in probiotics

• Fecal transplant
  – Replenish gut microbiome after antibiotics

• Phage therapy
  – Targeted bacterial killing
• Normal flora microbes can become pathogenic if they overgrow or reach new sites in the body: opportunistic pathogens

• Antibiotic-associated colitis is caused by *Clostridium difficile*

• Excessive antibiotic use kills normal flora: *C. difficile* overgrowth leads to toxin production and sporulation

• Spores from one patient can be transmitted to others

• Signs and symptoms: colitis, toxic megacolon, can lead to sepsis and death

*Clostridium difficile*
Novel Approach to Treating C. diff

“How Microbes Defend and Define Us”  The New York Times

By CARL ZIMMER, Published: July 12, 2010

- Patient suffering from *C. difficile* infection – diarrhea and wasting
- Dr. Khoruts gave her a transplant of bacteria: husband’s stool and saline delivered into her colon
- Disease symptoms vanished in a day

“Bacteriotherapy” or “Fecal Transplantation”

“Dr. Khoruts took a genetic survey of the bacteria in her intestines before and after the transplant. Before the transplant ‘The normal bacteria just didn’t exist in her. She was colonized by all sorts of misfits.’ Two weeks after the transplant, her husband’s microbes had taken over.... ‘That community was able to function and cure her disease in a matter of days.’”
Duodenal Infusion of Donor Feces for Recurrent *Clostridium difficile*

Els van Nood, M.D., Anne Vrieze, M.D., Max Nieuwdorp, M.D., Ph.D., Susana Fuentes, Ph.D., Erwin G. Zoetendal, Ph.D., Willem M. de Vos, Ph.D., Caroline E. Visser, M.D., Ph.D., Ed J. Kuijper, M.D., Ph.D., Joep F.W.M. Bartelsman, M.D., Jan G.P. Tijsen, Ph.D., Peter Speelman, M.D., Ph.D., Marcel G.W. Dijkgraaf, Ph.D., and Josbert J. Keller, M.D., Ph.D.


**RESULTS**

The study was stopped after an interim analysis. Of 16 patients in the infusion group, 13 (81%) had resolution of *C. difficile*-associated diarrhea after the first infusion. The 3 remaining patients received a second infusion with feces from a different donor, with resolution in 2 patients. Resolution of *C. difficile* infection occurred in 4 of 13 patients (31%) receiving vancomycin alone and in 3 of 13 patients (23%) receiving vancomycin with bowel lavage (*P*<0.001 for both comparisons with the infusion group). No significant differences in adverse events among the three study groups were observed except for mild diarrhea and abdominal cramping in the infusion group on the infusion day. After donor-feces infusion, patients showed increased fecal bacterial diversity, similar to that in healthy donors, with an increase in Bacteroidetes species and clostridium clusters IV and XIVa and a decrease in Proteobacteria species.

**CONCLUSIONS**

The infusion of donor feces was significantly more effective for the treatment of recurrent *C. difficile* infection than the use of vancomycin.
Fecal transplants to treat C. diff @ UCI

Dr. Nimisha Parekh establishing regular program @ UCI

Obtained IRB approval to receive material from OpenBiome in Boston

UC Irvine Healthcare

Dr. Nimisha Parekh finds enormous satisfaction in helping her patients live happy and productive lives.

Welcome to OPENBIOIME
Should We Bank Our Own Stool?

By MOISES VELASQUEZ-MANOFF  OCT. 9, 2015

Jesse Jacobs
**Timeline of Antibiotic Resistance**

Nearly as quickly as life-saving antibiotics are created, new drug-resistant infections appear.

**Antibiotics Introduced**
- *penicillin* 1943
- tetracycline 1950
- erythromycin 1953
- methicillin 1960
- gentamicin 1967
- vancomycin 1972
- imipenem and ceftazidime 1985
- ceftriaxone 2000
- ceftaroline 2010

**Antibiotic Resistance Identified**
- 1959 tetracycline–*Shigella*
- 1962 methicillin–*Staphylococcus*
- 1965 *penicillin*-R pneumococcus
- 1968 erythromycin–*Streptococcus*
- 1979 gentamicin–*Enterococcus*
- 1987 cefazidime–*Enterobacteriaceae*
- 1988 vancomycin–*Enterococcus*
- 1996 levofloxacin–*Pseudomonas*
- 1998 imipenem–*Enterobacteriaceae*
- 2001 linezolid–*Staphylococcus*
- 2002 vancomycin–*Staphylococcus*

**Yearly Antibiotic-Resistant Infections**

More than 2 million people in the U.S. are sickened every year with antibiotic-resistant infections. At least 23,000 die as a result.

**Antibiotics in Agriculture**

Of all antibiotics sold in the U.S. each year, 80 percent by weight are used in agriculture, primarily to fatten and protect animals.

**Before Antibiotics**

- 5 women died out of every 1,000 who gave birth.
- Three out of 10 who contracted pneumonia died.
- One out of every 10 people who got a skin infection from a scrape, a cut, or scratching a bite lost a limb.

*Penicillin-resistant* Staphylococcus appeared in 1962, three years before widespread use of the drug.

Source: Centers for Disease Control and Prevention.

Credits: Switched Media and Food & Environment Reporting Network.
Question

Do plain soap + water or 70% ethanol rubs, as opposed to antibiotic containing hand-gels, avoid promoting antibiotic resistant bacteria?

A. Yes

B. No
Do plain soap + water or 70% ethanol rubs, as opposed to antibiotic containing hand-gels, avoid promoting antibiotic resistant bacteria?

A. Yes
B. No
70% Alcohol Disinfectant

- 70% alcohol denatures proteins, dissolves lipids and can lead to cell membrane disintegration
- Effectively kills bacteria and fungi
  - Does not inactivate spores

https://www.youtube.com/watch?v=5tgH0uTqqcE
To limit the development of antibiotic resistance

- Only use antibiotics for bacterial infections
- Avoid use in agriculture and soap
- Identify the causative organism if possible
- Use a more specific antibiotic if possible; don't rely on broad range antibiotics
- Most colds, coughs, bronchitis, sinus infections, and eye infections are viral; do not use antibiotics

http://www.nytimes.com/2016/03/08/upshot/were-losing-the-race-against-antibiotic-resistance-but-theres-also-reason-for-hope.html

Fat, fibre and cancer risk in African Americans and rural Africans

- Two week diet swap between people from Florida and South Africa
- South Africans eat 50g fiber/day!
- Even high fiber diet study in US ~30g fiber/day
- In two weeks, pre-cancer biomarkers for colon cancer improved
Colorectal Cancer Incidence Among Young Adults in California

Kathryn E. Singh, MPH, MS,1 Thomas H. Taylor, PhD,2,3,4 Chuan-Ju G. Pan, MD,3,5 Michael J. Stamos, MD,6 and Jason A. Zell, DO, MPH2,3,4,5

1Division of Genetic and Genomic Medicine, Department of Pediatrics, University of California, Irvine, Irvine, California.

Eat like an African and drop your cancer risk in two weeks

Bill Karnes - colonoscopy microbiome sampling

ARTICLE

Received 23 May 2014 | Accepted 20 Jan 2015 | Published 28 Apr 2015

DOI: 10.1038/ncomms7342

Fat, fibre and cancer risk in African Americans and rural Africans
Manipulate the Microbiome

• Probiotics and prebiotics
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• Fecal transplant
  – Replenish gut microbiome after antibiotics

• Phage therapy
  – Targeted bacterial killing
Up-and-coming Projects

Ongoing:
• Early life / UC Pediatric Microbiome
• Metabolomics and diagnostics

Near term:
• Fecal transplant for C. diff
• Diet and colon cancer

Longer term:
• Later life / UC MIND
• Phage therapy
• Citizen science / undergraduate projects
Humans contain ~500,000 metabolites, half are produced or modified by microbes.
Cystic Fibrosis

- Most common inherited disorder among Caucasians
- Affects 1 in ~3000 in US
- Median life expectancy now ~40 in US
Antibiotics are a big part of increased life expectancy in CF

Slide from Prof. John LiPuma, NACFC 2014
Airway/sputum microbial community:
- *Pseudomonas aeruginosa*
- *Stenotrophomonas maltophilia*
- *Staphylococcus aureus*
- *Burkholderia* species
- Numerous others

Dense oral microbial communities:
- *Streptococcus* species
- *Rothia, Gamella* species & hundreds more

Exchange of volatile compounds

Altered microbial physiology? 

Adapted from Whiteson, K. et al (2014) “The Upper Respiratory Tract as a Microbial Source for Pulmonary Infections in Cystic Fibrosis. Parallels from Island Biogeography” *AJRCCM*

Illustration: Bryan Ramirez, Whiteson Lab, UCI
Correlation networks: anaerobes cluster away from gram negative opportunists

Co-occurrence network inferred from the SparCC algorithm applied to 16S rRNA gene data of 126 CF sputum samples from 6 patients.

Hypothesis: Microbial metabolites are good indicators of CF disease state
Microbial interactions mediated by volatile metabolites

NY Times 2012
Quantitative Analysis of Urine Vapor and Breath by Gas–Liquid Partition Chromatography

(orthomolecular medicine/vitamins/controlled diet)

LINUS PAULING*, ARTHUR B. ROBINSON*, ROY TERANISHI†, AND PAUL CARY*

* Department of Chemistry, Stanford University, Stanford, California 94305; and † Western Regional Laboratory, U.S. Department of Agriculture

Contributed by Linus Pauling, July 29, 1971
Human Breath Samples have microbial and human influences

Just blow  More than 99 percent of a person's exhaled breath consists of gases already present in the atmosphere. But the remaining 1 percent consists of volatile organic compounds, some of which rise and fall depending on the person's health, metabolic processes and environmental exposures.  SOURCE: R. DWEIK

www.sciencenews.org November 16, 2013
3 replicates of breath samples from each CF patient

1 simultaneous room sample

3 samples from healthy gender-matched controls who are in the room at the same time

Breath Gas Sampling Plan

Don Blake
Univ. of California Irvine

CF
Healthy
Room
Sampling canisters

- Air flow direction toggled by thumb
- Swagelok union tee
- Teflon tube
- Bellows valve
- Latex glove

2,3-Butanedione
- CF1
- Control

mV

11.0 - 11.2 min

Simone Meinardi
Blake Lab UCI
2,3-Butanedione

- A pH neutral fermentation product
  - Produced in low pH and low O$_2$ conditions
- Buttery flavor, important in dairy and wine industries
- Signals to microbes and hosts

Lesic and Rahme BMC Molecular Biology 2008 9:20
2,3-butanedione clearly elevated in CF

2,3-butane dione is not present during hospitalization and iv antibiotics

Antibiotic treatment history: all use Azithromycin chronically meropenem, tobramycin x 1 week, followed by Zosyn and tobramycin for 4 weeks
2,3-butanedione concentration itself may be destructive

“Our findings indicate that a safe level of exposure exists around or below a time-weighted average of 1 ppb for an eight-hour workday”. Egilman et al. (2011) A proposal for a safe exposure level for diacetyl. Int J Occup Environ Health. (2):122-34.
Approach

- Sputum
  - Microbial community DNA sequencing
  - Gas Chromatography (GC) & Mass Spec profiling
  - Liquid Chromatography (LC) & Mass Spec profiling
  - Culture models in capillary tubes

- Taxonomy Function
  - Small, volatile molecules (<200 Da)
  - Larger, more polar molecules (<2000 Da)

Rob Quinn, Yan Wei Lim, Rohwer Lab SDSU
Blood and breath levels of selected volatile organic compounds in healthy volunteers

Paweł Mochalski,*ab Julian King, a Martin Klieber, ac Karl Unterkofler, a Hartmann Hinterhuber, d Matthias Baumann* and Anton Amann*ac

Gas chromatography with mass spectrometric detection (GC-MS) was used to identify and quantify volatile organic compounds in the blood and breath of healthy individuals. Blood and breath volatiles were pre-concentrated using headspace solid phase micro-extraction (HS-SPME) and needle trap devices (NTDs), respectively. The study involved a group of 28 healthy test subjects and resulted in the quantification of effective than for its isomer. 2,3-Butanedione was ubiquitous in breath showing on average three times higher levels in exhaled air than in room air. However, the fact that it was never detected in blood suggests an exogenous source of this compound. Since 2,3-butanedione is a common constituent of butter it is conceivable that the oral cavity might act as a reservoir for this volatile. The remaining ketones (3-buten-2-one, 3-penten-2-one, etc.) were also detected in breath.
**Streptococcus** dominates butanediol pathway genes

![Diagram of metabolic pathways]

**Ion Torrent Data**
13 million reads, 7 samples, 7 CF patients
BLAST e-value >1e-5, 60bp and 90%id

Whiteson, K. et al (2014) *ISMEJ*
CF isolates of Strep and Rothia produce 2,3-butanedione

Grow cultures with $^{13}$C-glucose

Capture volatiles

Analyze with GC-MS

2,3-butanedione in breath indicates…

- Active *Strep/Rothia* metabolism
- Potential signal to *Pseudomonas*, increasing phenazine production
- Directly toxic to host

★ 2,3-Butanediolone

H₃C

★ A pH neutral fermentation product

**Whiteson, K. et al (2014) ISMEJ**
Detection of disease states through the microbiome

Fermentation
- Increase microbial virulence
- Directly toxic to host

Exacerbation
Humans contain ~500,000 metabolites, half are produced or modified by microbes.
Each metabolite has a story…

- **2,3-butanediol**
  - pH neutral fermentation product with buttery smell
  - Toxic, induces pyocyanin production in *Pseudomonas*

- **Putrescine**
  - Amino acid breakdown
  - Foul smell
  - A polyamine, binds DNA
  - Anti-inflammatory

- **5-aminovaleric acid**
  - Lysine degradation
  - Arginine and proline metabolism

- **Lactic acid**
  - Low pH fermentation product
  - Produced by *Streptococcus* spp. and lactic acid bacteria

- **Citric acid**
  - Low pH fermentation product or component of citric acid cycle

- **Ethanolamine**
  - Derived from cell membranes
  - Carbon & nitrogen source
A Do-It-Yourself Revolution in Diabetes Care

By PETER ANDREY SMITH  FEB. 22, 2016

John Costik, right, and his son Evan reflected on an iPad’s screen. An app on the device displays Evan’s blood sugar levels in real time. Brendan Bannon for The New York Times
Learning objectives

**Lecture Objectives - At the completion of this program, participants will know/be able to:**

1. Understand the differences between culture based and culture-independent approaches for assessing human microbes

2. Describe three culture independent, 'omic based approaches for profiling a clinical sample, and learn about resources available at UC Irvine

3. Critically review near-term applications of microbiome research (i.e. fecal transplant for Clostridia difficile infection, and Bifidobacter colonization in infants)

4. Analyze current issues impacting the potential for phage therapy to become a viable alternative to antibiotics

5. Apply knowledge obtained from the past 10 years of research, including the Human Microbiome Project to future infection treatment and potential reductions in autoimmune disease, allergy and cancer

Katrine Whiteson
Andrew Oliver and Stephen Wandro
University of California, Irvine
OLLI Oct 9, 2017

New website: microbiome.uci.edu

http://faculty.sites.uci.edu/whitesonlab/
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UC Davis Metabolomics Pilot
Gilead Research Scholars Program
Whiteson Lab Start-Up
ICTS
ACS Pilot
NSF IGERT & CVR
NIH
CFF

M A R K  H A T A Y
“E I N P H A G E”

http://faculty.sites.uci.edu/whitesonlab/
Additional Resources

1. Free coursera course about the microbiome led by Rob Knight lab members: [https://www.coursera.org/course/microbiome](https://www.coursera.org/course/microbiome)

2. A meeting at the NIH about the microbiome with videos and slides: [https://www.genome.gov/27554404](https://www.genome.gov/27554404)

3. An article about fecal transplants from The New Yorker: [http://www.newyorker.com/magazine/2014/12/01/excrement-experiment](http://www.newyorker.com/magazine/2014/12/01/excrement-experiment)

4. Here's another about the microbiome in the New Yorker: [http://www.newyorker.com/magazine/2012/10/22/germs-are-us](http://www.newyorker.com/magazine/2012/10/22/germs-are-us)

5. Another from Michael Pollen in the NY Times: [http://www.nytimes.com/2013/05/19/magazine/say-hello-to-the-100-trillion-bacteria-that-make-up-your-microbiome.html?pagewanted=all](http://www.nytimes.com/2013/05/19/magazine/say-hello-to-the-100-trillion-bacteria-that-make-up-your-microbiome.html?pagewanted=all)


9. Prof. Dan Knight's University of Minnesota Microbiome Course: [https://www.youtube.com/watch?v=Ok5h24KZbAE](https://www.youtube.com/watch?v=Ok5h24KZbAE)

New website: [microbiome.uci.edu](http://microbiome.uci.edu)