Genetics and Environment Influence Human Microbiome Composition

Hannah Tavalire, PhD
University of Oregon
Sexy Irish Drs. Calendar, 2015
What is the microbiome anyway???
What is the microbiome anyway???

- Microbes in and on your body

[https://en.wikipedia.org/wiki/Milky_Way; Sender et al., 2016*](https://en.wikipedia.org/wiki/Milky_Way; Sender et al., 2016*)
What is the microbiome anyway???

• Microbes in and on your body
• TRILLIONS
  – Mostly bacteria
  – Some Archaea & Fungi

https://en.wikipedia.org/wiki/Milky_Way; Sender et al., 2016*
What is the microbiome anyway???

- Microbes in and on your body
- TRILLIONS
  - Mostly bacteria
  - Some Archaea & Fungi
- \(~0.5\text{lbs}\)*

* [Milky Way](https://en.wikipedia.org/wiki/Milky_Way); Sender et al., 2016*
What is the microbiome anyway???

- Microbes in and on your body
- TRILLIONS
  - Mostly bacteria
  - Some Archaea & Fungi
- ~0.5lbs*
- Every microbiome is unique!

https://en.wikipedia.org/wiki/Milky_Way; Sender et al., 2016*
What do we know about it???

- Research Timeline
What do we know about it???

• Research Timeline

  –~2001: ‘microbiome’ term emerges (debatable)

Prescott, 2017
What do we know about it???

• Research Timeline

  – ~2001: ‘microbiome’ term emerges (debatable)

  – 2001-2008: The field of meta-genomics grows—especially involving the microbiome

Prescott, 2017
What do we know about it??

• Research Timeline

  – ~2001: ‘microbiome’ term emerges (debatable)
  
  – 2001-2008: The field of meta-genomics grows- especially involving the microbiome

• Sequencing got REALLY cheap
What do we know about it???

• Research Timeline
  – 2008: The Human Microbiome Project

What do we know about it??

• Research Timeline
  – 2008: The Human Microbiome Project
• NIH common fund

What do we know about it???

• Research Timeline
  – 2008: The Human Microbiome Project
    • NIH common fund
    • 300 people
    • 15 body sites

What do we know about it???

• Research Timeline
  – 2008: The Human Microbiome Project
    • NIH common fund
    • 300 people
    • 15 body sites
    • Publically available and still being used!
What do we know about it???

- 2008-2018: HMP major findings (adults)
  - General composition

Spor et al 2011; https://commonfund.nih.gov/hmp/
What do we know about it???

- 2008-2018: HMP major findings (adults)
  - General composition

Spor et al 2011; https://commonfund.nih.gov/hmp/
What do we know about it???

• 2008-2018: HMP major findings (adults)
  – General composition

Spor et al 2011; https://commonfund.nih.gov/hmp/
What do we know about it???

- Select findings (HMP and beyond)
  - Composition

Photo: NASA; Chong et al., 2015; Lin et al., 2013; Yasir er al., 2015; Yatsunenko et al, 2012
What do we know about it???

• Select findings (HMP and beyond)
  —Composition
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photo: NASA; Chong et al., 2015; Lin et al., 2013; Yasir er al., 2015; Yatsunenko et al, 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photo: NASA; Chong et al., 2015; Lin et al., 2013; Yasir er al., 2015; Yatsunenko et al, 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photos: [http://artoftall.com](http://artoftall.com); [https://www.davidwolfe.com](https://www.davidwolfe.com); [http://news.mit.edu](http://news.mit.edu); [http://www.aaiclinics.com](http://www.aaiclinics.com); Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photos: [http://artoftall.com](http://artoftall.com); [https://www.davidwolfe.com](https://www.davidwolfe.com); [http://news.mit.edu](http://news.mit.edu); [http://www.aaiclinics.com](http://www.aaiclinics.com); Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

- Select findings (HMP and beyond)
  - Composition

Photos: [http://artofall.com](http://artofall.com); [https://www.davidwolfe.com](https://www.davidwolfe.com); [http://news.mit.edu](http://news.mit.edu); [http://www.aaclinics.com](http://www.aaclinics.com); Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photos: [http://arttall.com](http://arttall.com); [https://www.davidwolfe.com](https://www.davidwolfe.com); [http://news.mit.edu](http://news.mit.edu); [http://www.aarclinics.com](http://www.aarclinics.com); Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photos: http://artontall.com; https://www.davidwolfe.com; http://news.mit.edu; http://www.aarcinics.com; Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

• Select findings (HMP and beyond)
  – Composition

Photos: http://artortali.com; https://www.davidwolfe.com; http://news.mit.edu; http://www.aarclinics.com; Blackhed et al., 2010; Chang et al., 2015; Chu et al., 2016; Jumpertz et al., 2011; Xu et al., 2015; Sordillo et al., 2017; Stearns et al., 2017; Thompson et al., 2012
What do we know about it???

• Major findings (HMP and beyond)
  – The microbiome has been directly tied to obesity and metabolism

Walker and Parkhill, 2013
What do we know about it???

• Major findings (HMP and beyond)
  – The microbiome has been directly tied to obesity and metabolism

Walker and Parkhill, 2013
What do we know about it???

• **Major findings (HMP and beyond)**
  – The microbiome has been directly tied to obesity and metabolism.

Walker and Parkhill, 2013
What do we know about it???

- Major findings (HMP and beyond)
  - The microbiome has been directly tied to

Walker and Parkhill, 2013
What do we know about it???

• Major findings (HMP and beyond)
  –The microbiome has been directly tied to...

Walker and Parkhill, 2013
What do we know about it???

• Major findings (HMP and beyond)
  – The microbiome has been directly tied to immunity
Major findings

- The microbiome has been directly tied to immunity.

Photos: Harm et al., 2014; Hall et al., 2017; Leifer et al., 2014; Schirmer et al., 2016
Major findings:

- The microbiome has been directly tied to immunity.

Photos: Harm et al., 2014; Hall et al., 2017; Leifer et al., 2014; Schirmer et al., 2016
The microbiome has been directly tied to immunity.

Major findings:
- The microbiome is crucial for immune development.

Photos: Harm et al., 2014; Hall et al., 2017; Leifer et al., 2014; Schirmer et al., 2016
What do we know about it???

• Major findings (outside of HMP)
  – The microbiome has been directly tied to neurodevelopment

Photo: Cryan et al., 2012; Aarts et al., 2017; Berding and Donovan, 2016; Herpertz-Dahlmann et al., 2017; Kiraly et al., 2016; Mayer et al., 2014
What do we know about it???

- Major findings (outside of HMP)
  - The microbiome has been directly tied to neurodevelopment

Photo: Cryan et al., 2012; Aarts et al., 2017; Berding and Donovan, 2016; Herpertz-Dahlmann et al., 2017; Kiraly et al., 2016; Mayer et al., 2014
Where is the research going???

• The MB as a source of non-host genetic variation...

Grice et al., 2012; Foxman et al., 2015; Karlsson et al., 2014; Preidis et al., 2009; Shapiro et al., 2017
Where is the research going???

• The MB as a source of non-host genetic variation...
  – Disease prevention
  – Personalized medicine

Grice et al., 2012; Foxman et al., 2015; Karlsson et al., 2014; Preidis et al., 2009; Shapiro et al., 2017
Where is the research going???

- The MB as a source of non-host genetic variation
  - Disease prevention
  - Personalized medicine

Grice et al., 2012; Foxman et al., 2015; Karlsson et al., 2014; Preidis et al., 2009; Shapiro et al., 2017
Where is the research going???

- The MB as a source of non-host genetic variation
  - Disease prevention
  - Personalized medicine

Grice et al., 2012; Foxman et al., 2015; Karlsson et al., 2014; Preidis et al., 2009; Shapiro et al., 2017
How do we measure it in humans?

Sue went over main collection and lab methods...
Thanks, Sue!
How do we measure it in humans?

Sue went over main collection and lab methods...
Thanks, Sue!

https://uoitbio2013.wordpress.com/taxonomy/biodiversity/
How do we measure it in humans?

Sue went over main collection and lab methods...
Thanks, Sue!

https://uoitbio2013.wordpress.com/taxonomy/biodiversity/
How do we measure it in humans?

Sue went over main collection and lab methods...
Thanks, Sue!
How do we measure it in humans?

Sue went over main collection and lab methods... Thanks, Sue!
Spor et al. 2011; https://commonfund.nih.gov/hmp/
The Early Growth and Development Study

~1000 children across the US

Nature versus nurture in an adoption design

Genetic background is not confounded by environment!!
The Early Growth and Development Study

Microbiome Pilot

80 children

34 homes

~3000 unique bacterial types identified
Preliminary Results

Overall diversity:

~4% total variation explained...

Most explained by age and shared environment
Preliminary Results

Specific Taxa:

76 heritable (76/3000 = ~2.5%)

5 env. influence (5/3000 = ~0.17%)

More rare species!

More abundant species!
Preliminary Results

Summary:
Preliminary Results
Summary:
Agrees with previous findings that each microbiome is unique
Preliminary Results
Summary:
Agrees with previous findings that each microbiome is unique
Env versus genetic influence seems to depend on species... but env ‘matters’ more
Preliminary Results

Summary:
Agrees with previous findings that each microbiome is unique
Env versus genetic influence seems to depend on species... but env ‘matters’ more

Environment dominates over host genetics in shaping human gut microbiota

Daphna Rothschild¹,², Omer Weissbrod¹,², Elad Barkan¹,², Alexander Kurilshikov³, Tal Korem¹,², David Zeevi¹,², Paul I. Costea¹,², Anastasla Godneva¹,², Iris N. Kalka¹,², Noam Bar¹,², Smadar Shillo¹,², Dar Lador¹,², Arnau Vich Vila³,⁴, Niv Zmora⁵,⁶,⁷, Meirny Peyser-Fischer³, David Israeli⁸, Noa Kosower¹,², Gal Malka¹,², Bat Chen Wolf¹,², Tali Aynit-Sagl¹,², Maya Lotan-Pompan¹,², Adina Weinberger¹,², Zamir Halpern⁷,⁹, Shai Carmi¹⁰, Jingyuan Fu³,¹¹, Cisca Wijmenga³,¹², Alexandra Zhernakova³, Eran Elinav⁵,⁶ & Eran Segal¹,²
Future Work

Integrate other aspects of environment

Look at higher levels of organization
Questions?


Sender et al., 2016. Revised Estimates for the Number of Human and Bacteria Cells in the Body. PLOS Biology.


What do we know about it???

• 2008-2018: HMP major findings (adults)
  – Diet affects composition
  – The microbiome has a circadian rhythm that influences our own
  – The microbiome and immune system are intimately connected
    • Monitoring the microbiome can give early indication of inflammatory disease

https://commonfund.nih.gov/hmp/
What do we know about it???