City-Scale Metagenomics

@mason_lab

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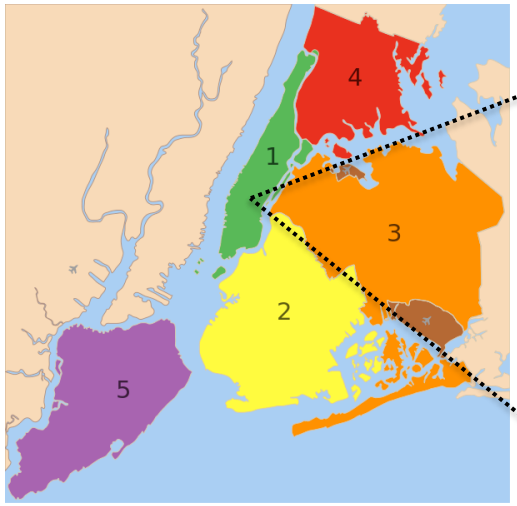
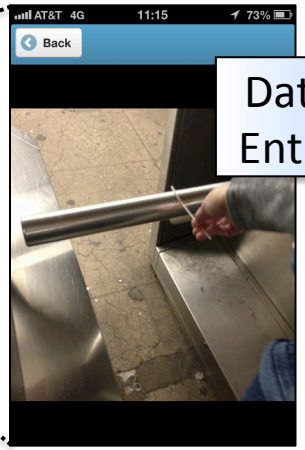
Tri-Institutional Program on Computational Biology and Medicine
Fellow of the Information Society Project, Yale Law School

June 20th , 2015

Elizabeth Hénaff / CartoDB

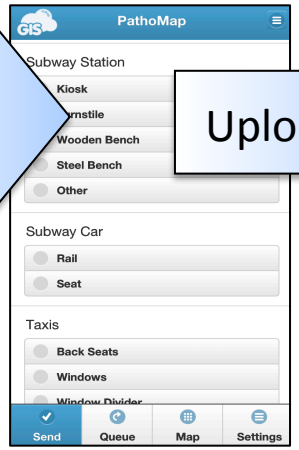


1. Swab (3 min)



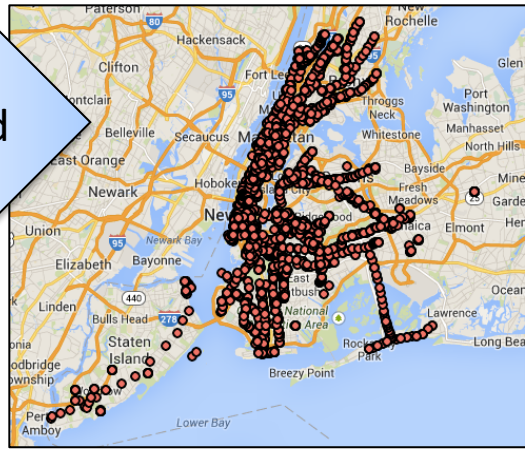
Data Entry

2. Annotate



Upload

3. GPS-tag/timestamp



Extract DNA (n=1,457 samples)

↓

96-plex TruSeq/Qiagen Libraries

↓

10 billion 125x125 DNA Fragments

↓

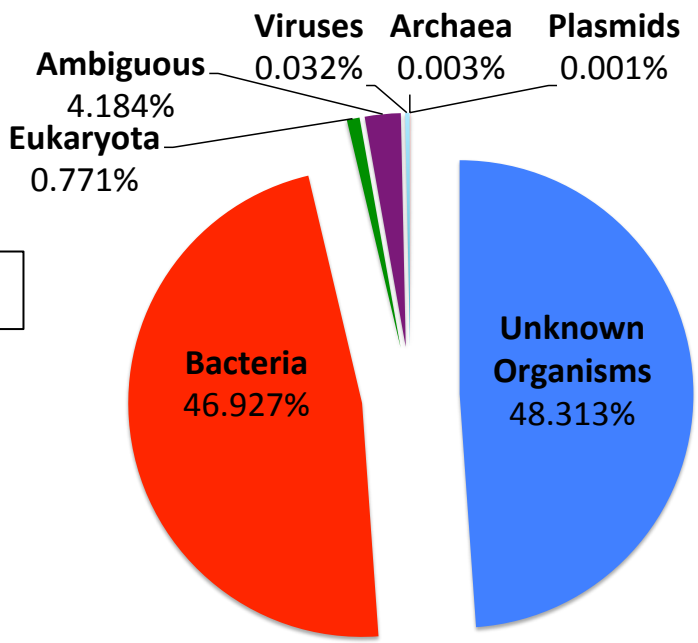
Quality Trim (Q20)

↓

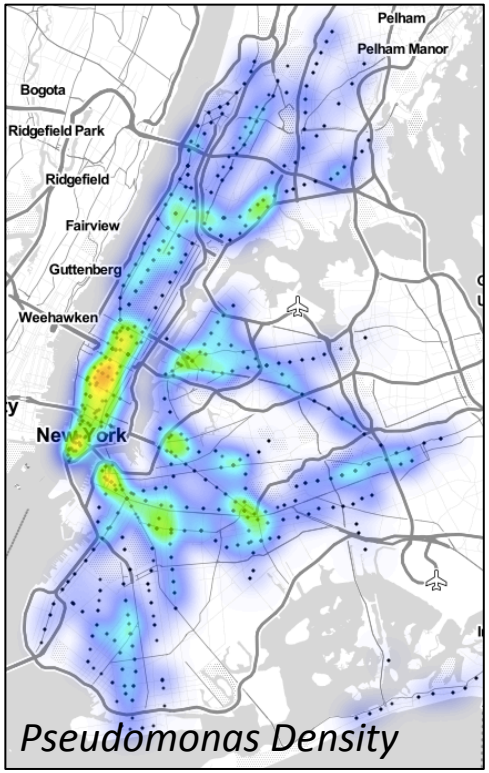
MegaBLAST-LCA alignment

↓

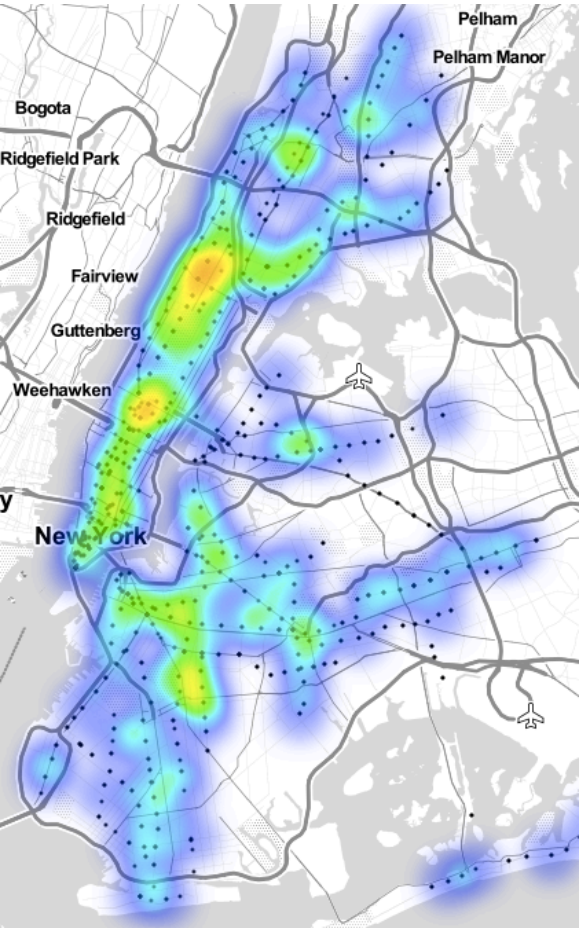
Confirm with MetaPhlAN



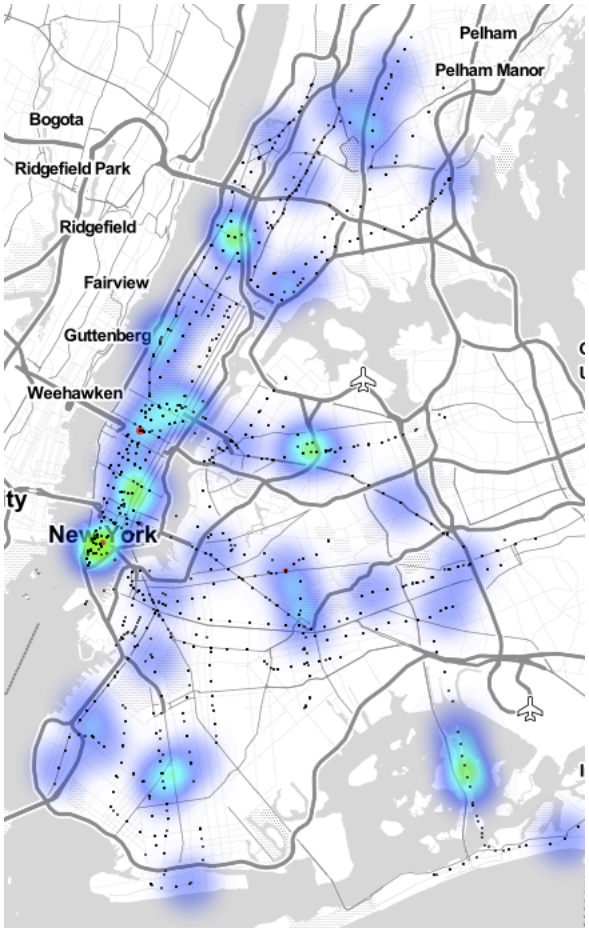
Half of the world under our fingertips is unknown



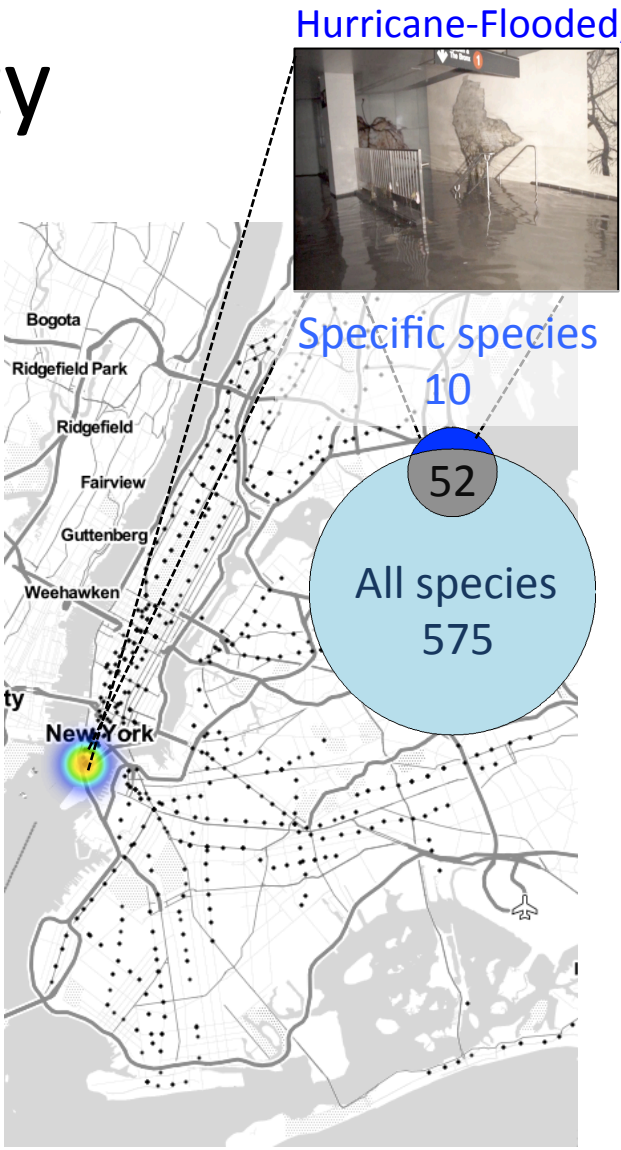
Species diversity varies by area of the city



Enterococcus faecium



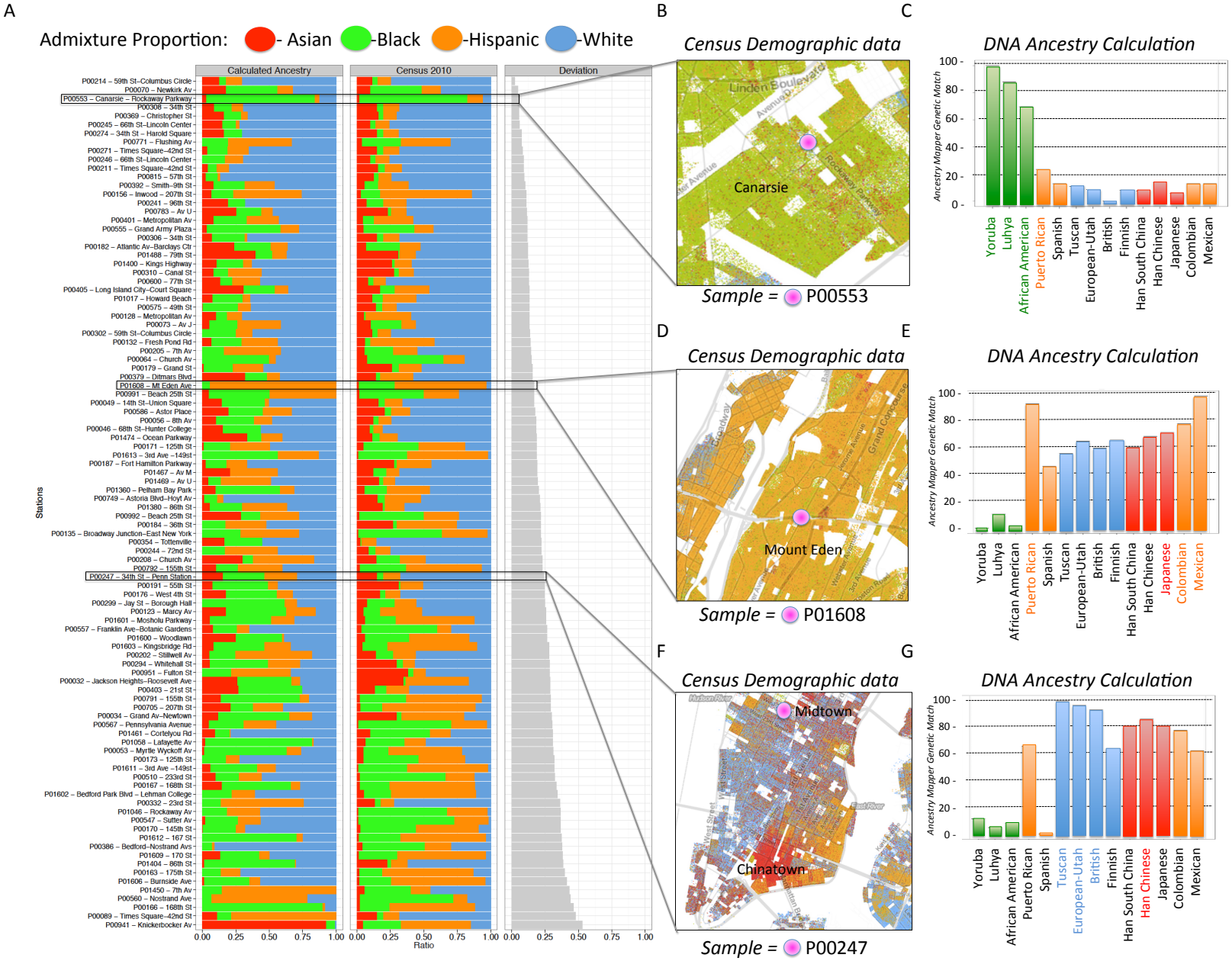
Staphylococcus aureus



Pseudoalteromonas haloplanktis

Afshinnekoo *et al.*, Cell Systems, 2015

We can detect humans' "molecular echo"

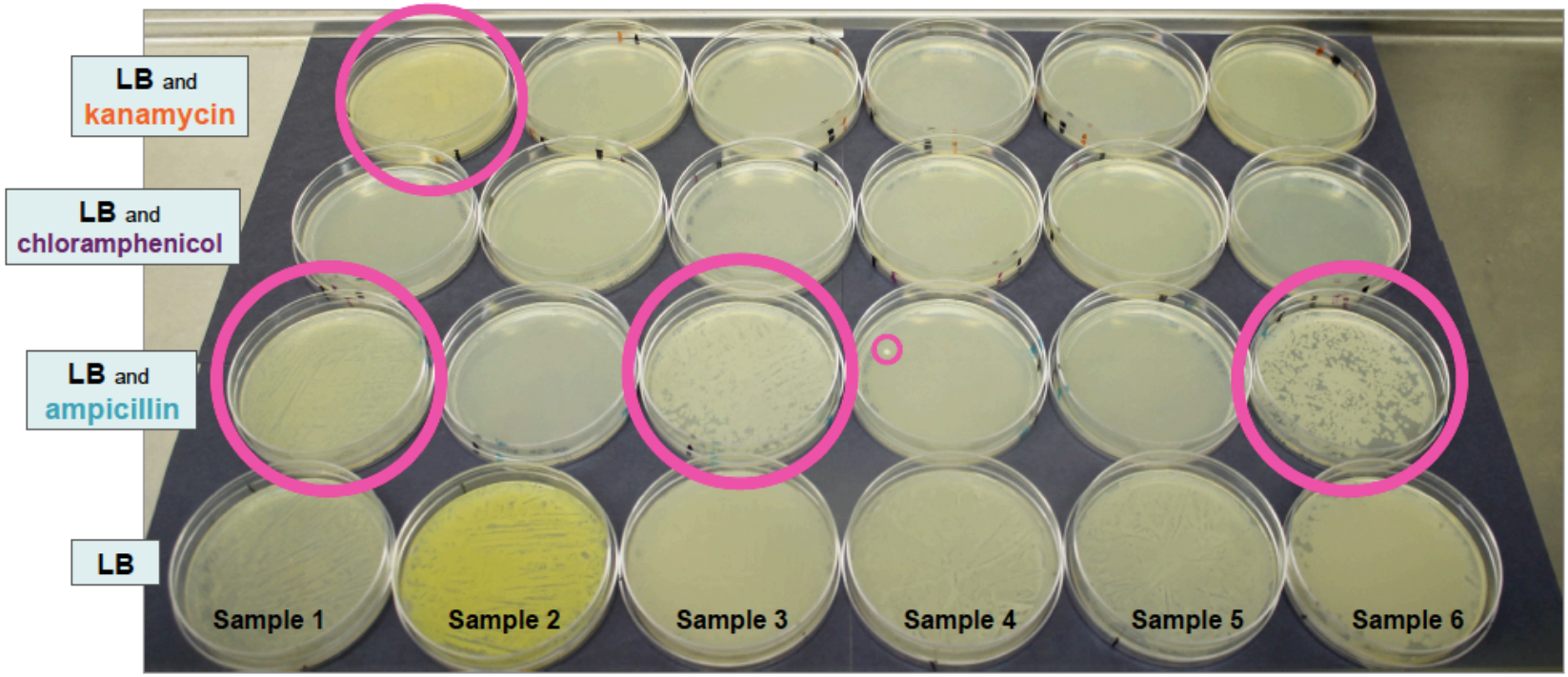


Afshinnekoo *et al.*, Cell Systems, 2015

Evidence of live & antibiotic resistant bacteria

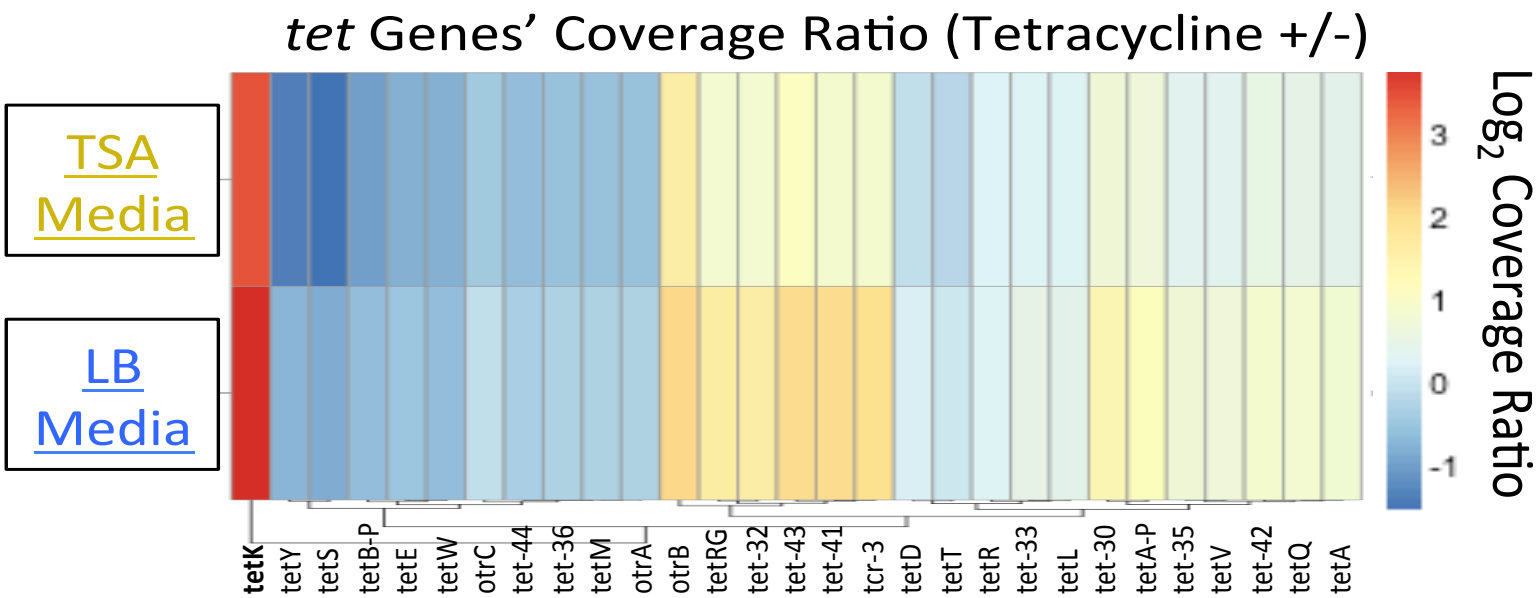
Bacterial Growth from Subway Station Samples on Antibiotic Plates

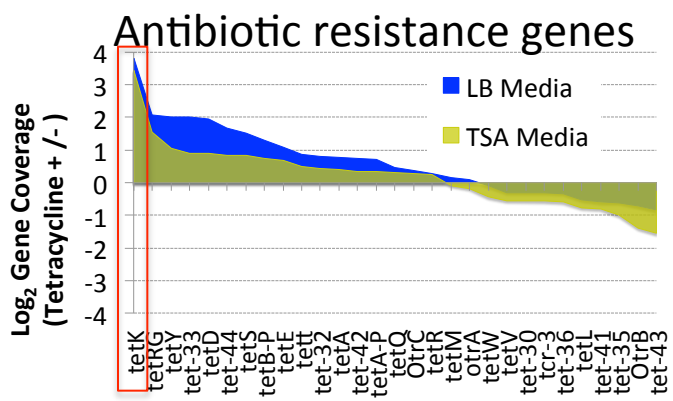
	Sample 1 63rd St.	Sample 2 63rd St.	Sample 3 68th St.	Sample 4 96th St.	Sample 5 77th St.	Sample 6 77th St.
LB + kanamycin	growth	no growth	no growth	no growth	no growth	no growth
LB + chloramphenicol	no growth	no growth	no growth	no growth	no growth	no growth
LB + ampicillin	growth	no growth	growth	one colony	no growth	growth
LB	growth	growth	growth	growth	growth	growth



Afshinnekoo *et al.*, Cell Systems, 2015

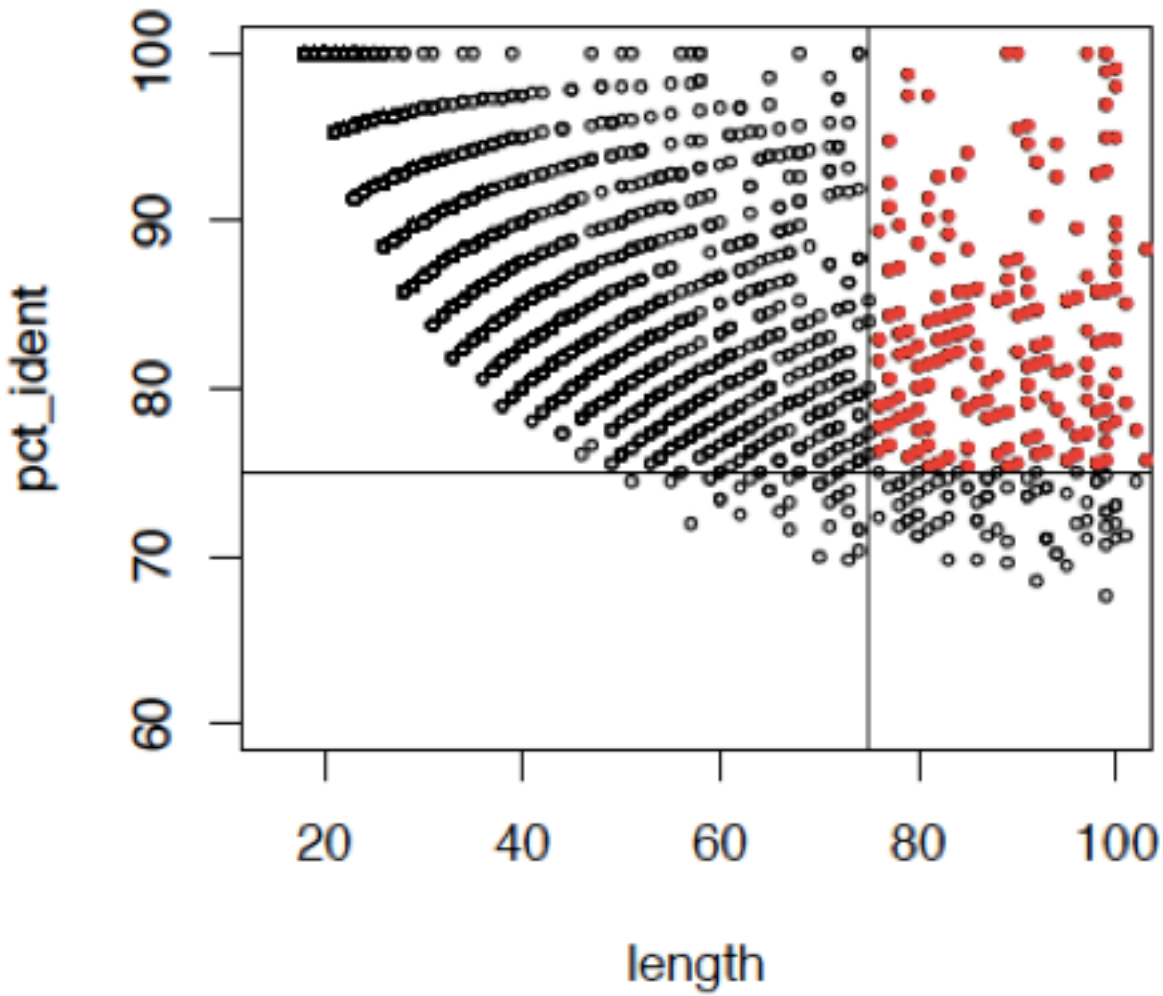
Metagenomics reveals the likely source of Tetracycline resistance (TetK) on both media





Afshinnekoo *et al.*, Cell Systems, 2015

We focused on the red, high confidence parts. Still matched >15,000 species



THE WALL STREET JOURNAL. | U.S.

15123

2833

HEALTH POLICY

Big Data and Bacteria: Mapping the New York Subway's DNA

Scientists in 18-Month Project Gather DNA Throughout Transit System to Identify Germs, Study Urban Microbiology

The Washington Post

Search

Morning Mix

From beetles to bubonic plague: Bizarre DNA found in NYC subway stations

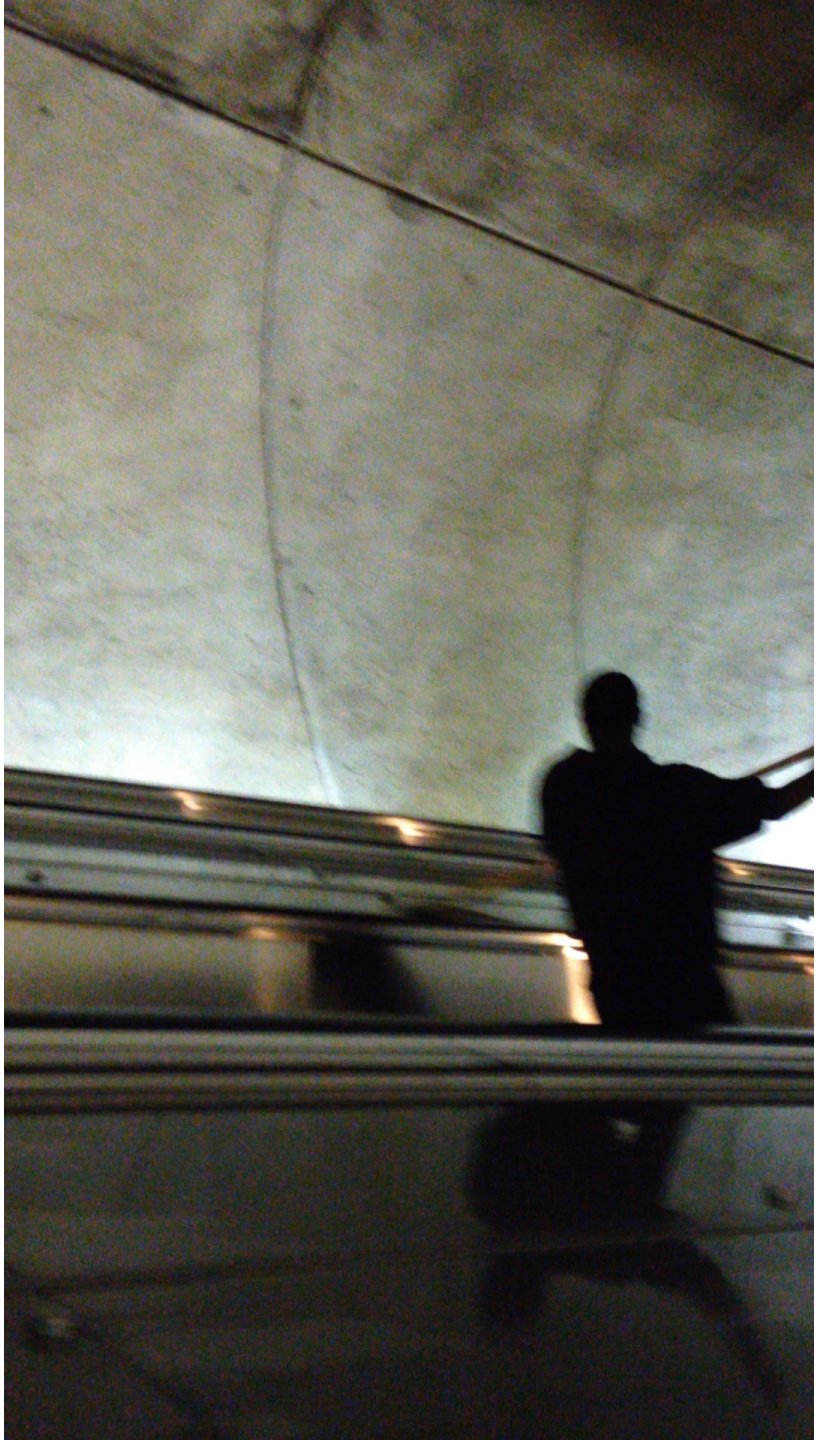
POPULAR SCIENCE

TRACES OF BUBONIC PLAGUE AND DYSENTERY FOUND IN NEW YORK'S SUBWAY SYSTEM

BUT DON'T THROW AWAY YOUR METROCARD JUST YET

By Lydia Ramsey Posted February 5, 2015

Washington
D.C.



Shanghai

Global Context

www.metasub.org

		City Details						Site Principal Investigator		
Site	Status	City	Country	Total # Stations	Transit System Length (km)	Riders / year (billions)	Population (people)	Department	University / Institute	Contact PI
1	Ongoing	Beijing	China	318	527	3.387	21,150,000	Beijing Children's Hospital	Capital Medical University	Yongli Guo
2	Planned	Seoul	South Korea	377	464	2.563	10,117,909	Genome Standards Consortium	Macrogen	Changhoon Kim
3	Ongoing	Shanghai	China	337	548	2.519	24,150,000	Personalized Genomics	Fudan University	Leming Shi
4	Need PI	Moscow	Russia	196	328	2.491	11,503,501	TBD	TBD	TBD
5	Planned	Tokyo	Japan	295	316	2.351	13,185,502	Department of Integrative Genomics,	Tohoku University	Haruo Suzuki
6	Ongoing	Guangzhou	China	130	240	2.280	12,700,800	Systems Biology	Sun Yat-sen University	Zhi Xie
7	Ongoing	New York City	USA	468	436	1.708	8,405,837	Physiology and Biophysics	Weill Cornell Medical College	Christopher Mason
8	Planned	Mexico City	Mexico	195	227	1.685	8,851,080	National Institute of Public Health	IANPHI Mexico Secretariat	Jesus Martinez Barnetche
9	Ongoing	Hong Kong	China	87	175	1.618	7,219,700	Computer Science and Engineering	City University	Patrick Lee
10	Planned	Paris	France	303	214	1.527	2,273,305	Analytical Genomics	University Pierre et Marie Curie	Hugues Richard
11	Planned	London	UK	270	402	1.261	8,615,246	Infectious Disease Epidemiology	Imperial College	David Aanensen
12	Ongoing	Barcelona	Spain	131	178	1.036	4,576,394	Genomic and Epigenomic Variation	Centre for Genomic	Stephan Ossowski
13	Planned	Singapore	Singapore	113	153	0.922	5,399,343	Biochemistry and Molecular Biology	Pennsylvania State University	Stephan Schuster
14	Ongoing	São Paulo	Brasil	65	75	0.921	11,895,893	Genetics and Bioinformatics	University of Sao Paolo	Houtan Noushmehr
15	Ongoing	Boston	USA	51	61	0.166	4,180,000	Biostatistics	Harvard School of Public Health	Curtis Huttenhower
16	Ongoing	Sydney	Australia	7	15	0.031	4,576,394	Computational Metagenomics	University of Technology	Aaron Darling

Extreme Context

www.extrememicrobiome.org

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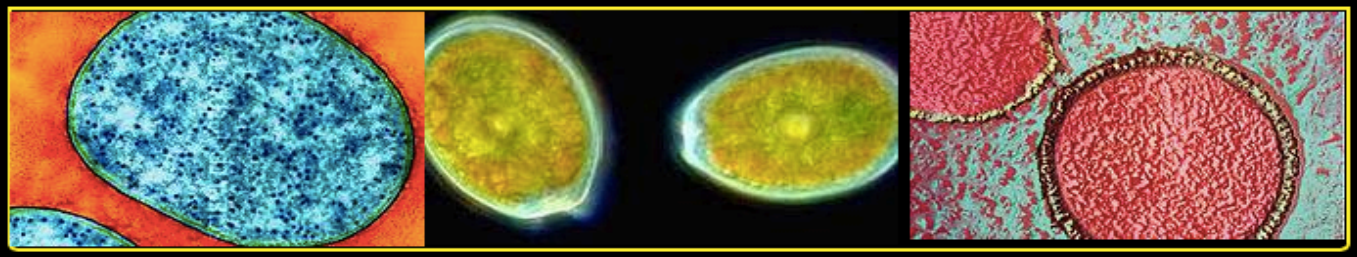
Xtreme Microbiome XMP Project

Finding new genes
From the strangest organisms
In the strangest places

HOME ABOUT PEOPLE PROJECTS METHODS COLLABORATORS LINKS CONTACT



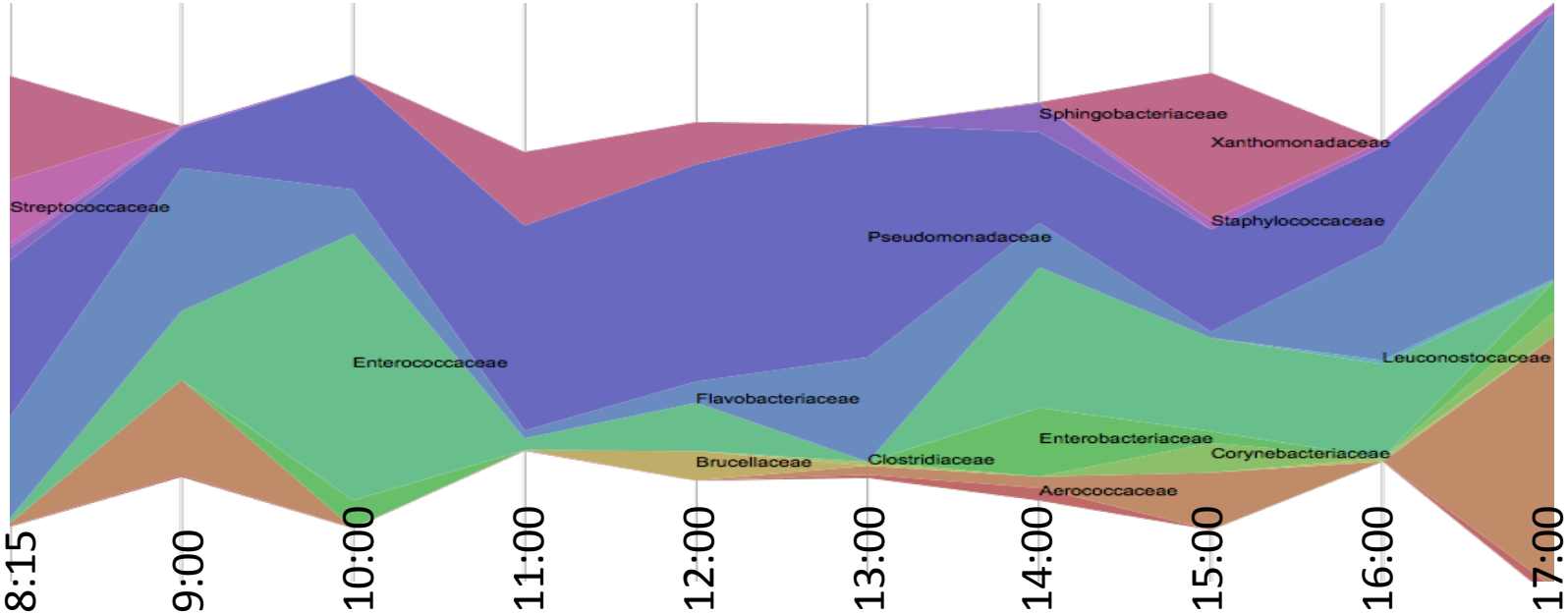
The eXtreme Microbiome Project (XMP) is a scientific effort to characterize, discover, and develop new pipelines and protocols for extremophiles and novel organisms. It was initiatied as part of the Association of Biomolecular Resource Facilities (ABRF) Metagenomics Research Group (MGRG) in 2014 as a consortium of microbiologists, geneticists, oceanographers, and bioinformaticists.

What makes XMP different from other microbiome projects? Click Here.

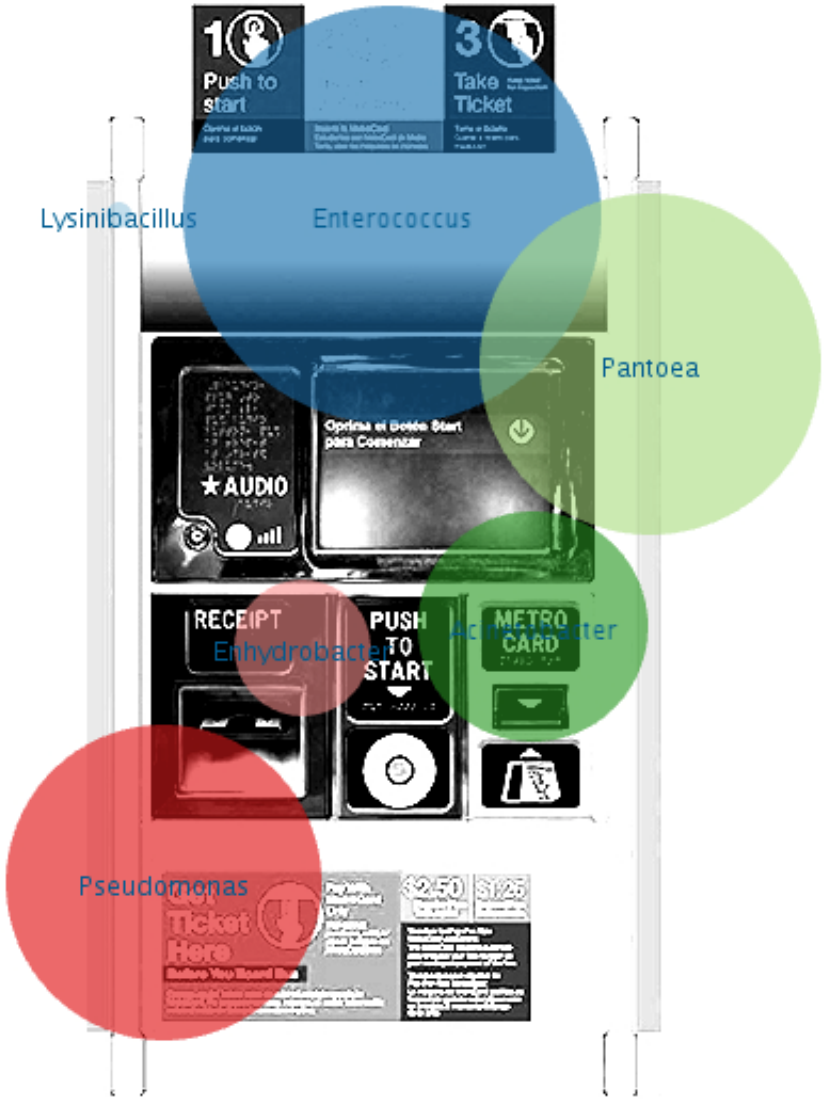
http:/www.extrememicrobiome.org

Time

Hourly dynamics of a populated kiosk are far more heterogeneous



Afshinnekoo *et al.*, Cell Systems, 2015



http://www.pathomap.org/2015/02/05/gc-timecourse/

Afshinnekoo *et al.*, Cell Systems, 2015

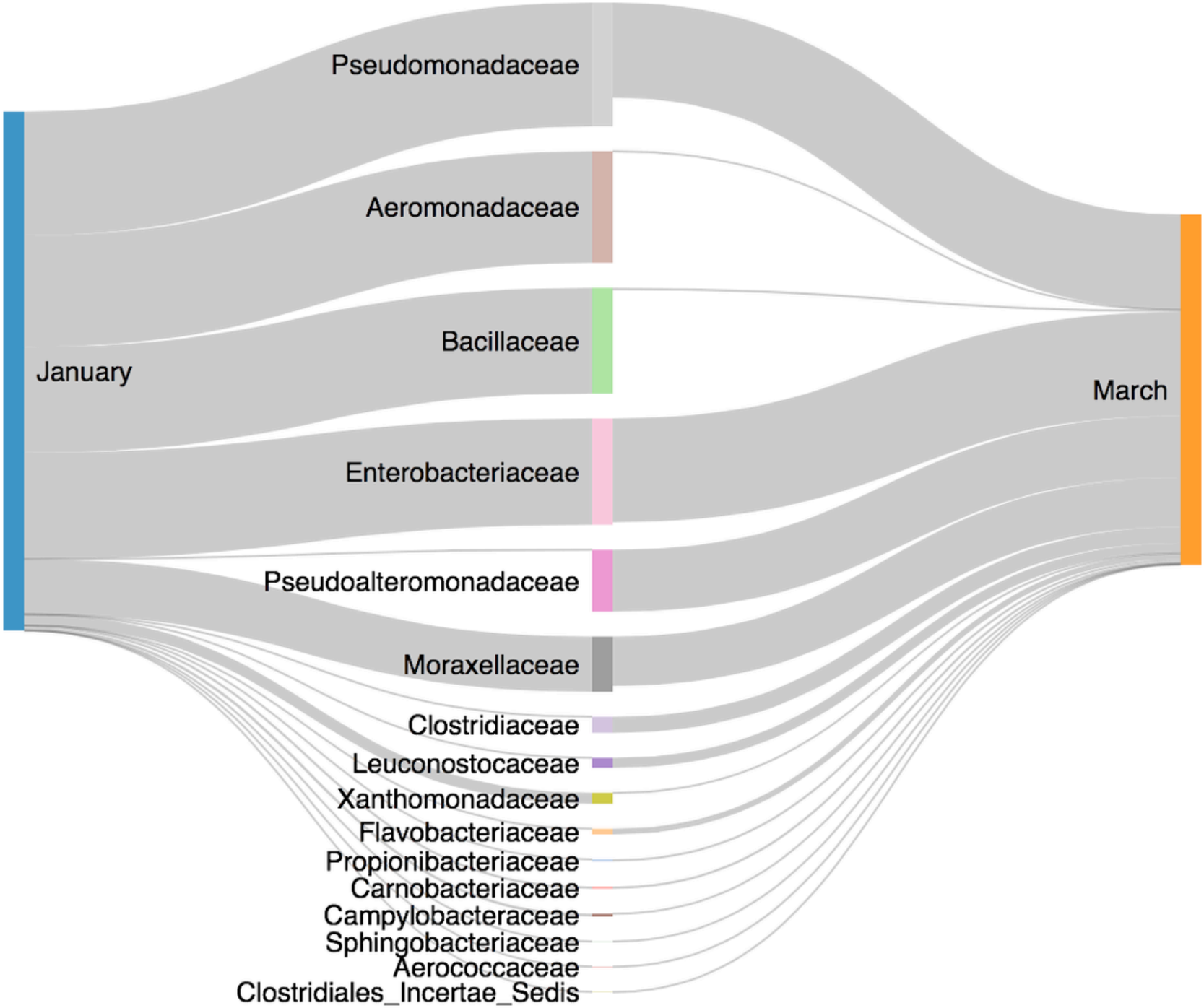
10 Seasonal Microbiome Collections

2013-4
Autumn

2013-4
Winter

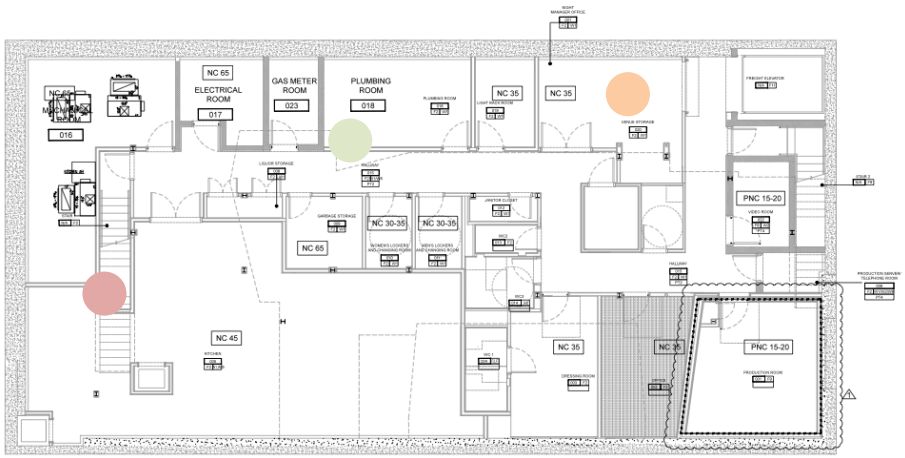
2013-5
Spring

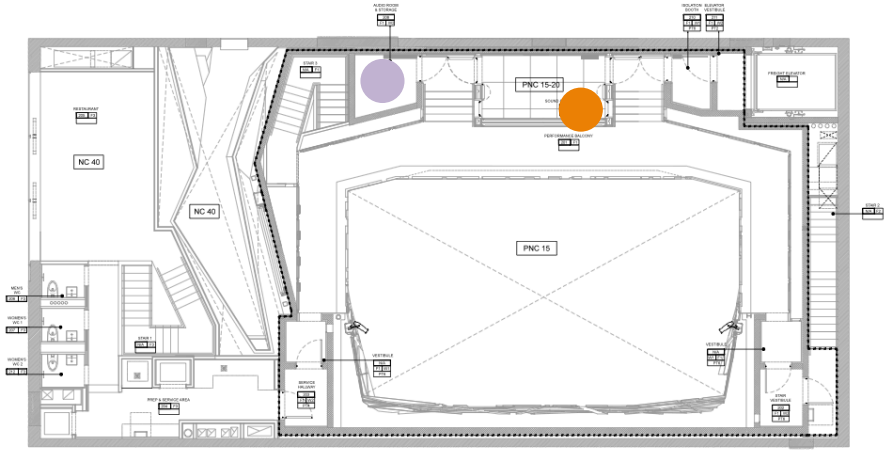
2013-5
Summer

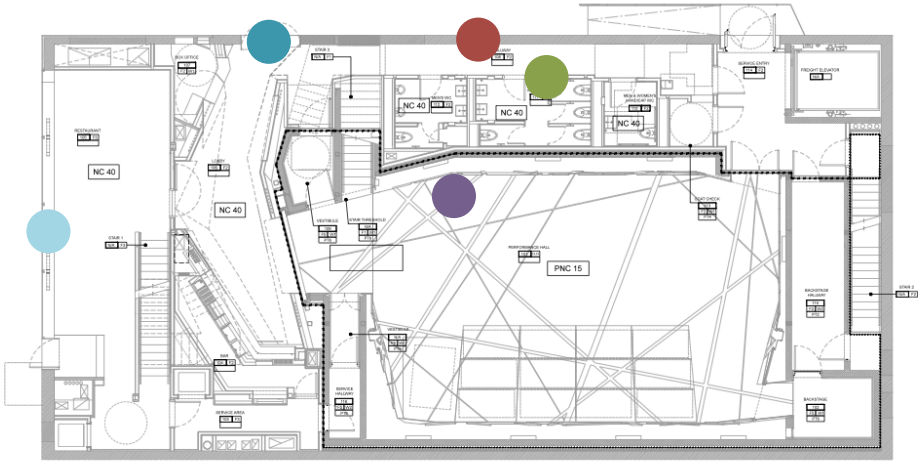

Pseudomonadaceae
Aeromonadaceae
Bacillaceae
January
Enterobacteriaceae
March
Pseudoalteromonadaceae
Moraxellaceae
Clostridiaceae
Leuconostocaceae
Xanthomonadaceae
Flavobacteriaceae
Propionibacteriaceae
Carnobacteriaceae
Campylobacteraceae
Sphingobacteriaceae
Aerococcaceae
Clostridiales_Incertae_Sedis

Space

Metagenome of building materials throughout construction and human occupancy can change





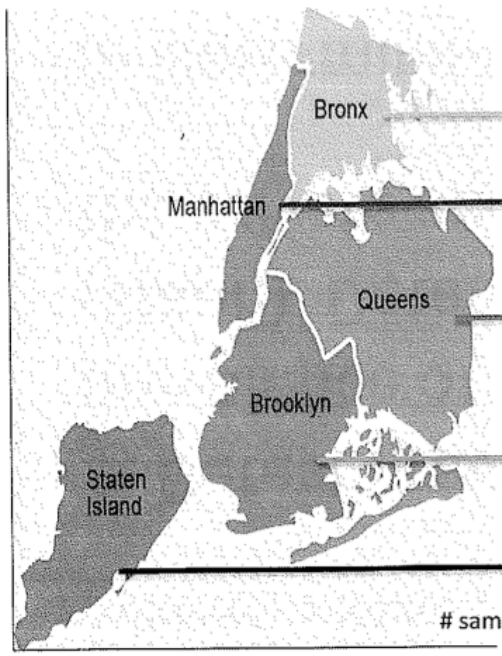


Traffic

low	high	
		dry wall
		brick
		glass
		metal
		wood

Catgory	# of Fields	Data Fields (taken from the NYC layer of the app), also using input from the Open Source Building Science Sensors (OSBSS) metadata
Surface Composition	9	Metal, Wood, Plastic, Ceramic, Metal, Leather, Concrete, Glass, Other
Surface Type	8	Kiosk, Turnstile, Bench, Railing, Handrail, Garbage Can, Payphone, Other
Surface Porosity	3	Hermetically sealed, Porous, Absorbant
Cleaning Frequncy	1	Frequency per day
Cleaning Type	1	Text for detergeny or methods used
Human Activity	3	Video, IR, and observational estimates of # of people
Surface Location	3	Floor, Middle, Ceiling
Air flow	2	Speed and filter type
Air vents	3	Number of input and output vents
Subway Lines	22	1, 2, 3, 4, 5, 6, 7, A, C, E, B, D, F, M, G, J, Z, L, S, N, Q R
Subway Stations	468	Auto-complete from Form
Subway Car Position	3	First Car, N+1 Car, Last Car
Train ID	1	Train# 4673
Temperature	1	Range from -50°F to 150°F
Humidity	1	Range from -50°F to 150°F
Taxi Surfaces	6	Back seats, Front Seats, Divider, Door, TV monitor, Other
Airport Surfaces	5	Door Railing, Screen for Check-In, Escalator Railing, Seats, Bathroom Handles
Park Surfaces	9	Bench, Handrailing, Water Fountain, Slide, Monkey Bars, Swings, Trash Can, Lamp Post, Other
Bus Surfaces	5	Front Door, Back Door, Seat, Rail, Other
Traffic	3	High, Medium, Low
Audio	3	Record, Play, Delete
Manual Time Entry	1	Time-stamp back-up field
Photograph	1	iOS or Andriod-based

Integrate all molecular and technical data into a “smart city” and then a “smart globe”



						Public Hospital entrance banister &		Sewage	Bus station public restroom/ park bench observatory*	
Bronx	10x5	50x3	10	5	5	2x5	10x4	5	10	285
Manhattan	10x5	50x3	10	5	5	2x5	10x4	5	10	285
Queens	10x5	50x3	10	5	5	2x5	10x4	5	10	285
Brooklyn	10x5	50x3	10	5	5	2x5	10x4	5	10	285
Staten Island	10x5	50x3	10	5	5	2x5	10x4	5	10	285
# samples	250	50x	50	25	25	50	10x	25	50	1425

with Center for Urban Science and Progress (CUSP) in NYC

Global Collection Status

pathomap.giscloud.com

agbt

Patho MAP

Search...

1:147914678

19293928.9316, 1291480.0299

owner	car_location	CREATED	Sample Number	Place	Surface type	Place name	Subway Line	Subway Station	Subway station s	Subway c
pmvolunteer		12/8/2014 4:0...	184	sub_line	Ceramic		G	Fulton St	Other	
masonlab		8/4/2014 3:37...	P1402041	sub_line	Ceramic	L train floor	L			
pmvolunteer		12/8/2014 11:...	161	sub_line	Ceramic		N	86th St		
pmvolunteer		12/8/2014 1:3...	176	sub_line	Ceramic		G	Fort Hamilton ...	Other	
pmvolunteer		11/3/2014 9:5...	f150074	sub_line	Ceramic	86th st	D	25th Av	Other	
pmvolunteer		11/30/2014 9:...	F140236	sub_line	Ceramic		E	Queens Plaza	Other	

10 | 1 / 422 | 1..10 / 4211 | Show only selected