

Term Project Summary

This project looks into the process of bacterial conjugation as well as its impact on the species of bacteria as a biological kingdom. Conjugation is a reproductive process in which two bacteria transfer/share genetic material resulting in traits being developed between the two, which can then be transferred to offspring that are replicated from either cell.

Bacteria do not necessarily look for a mate that will help them to reproduce offspring, but instead seek out genes and DNA that can be taken in and replicated, and as such this concept of sexual selection is entirely dependent on simply how many of these “desired” genes a particular cell has. As a bacterial cell reproduces, it essentially duplicates itself with a copy of genes it might have acquired through the process of conjugation, which can, in turn, continue to conjugate with other cells that contain genes that are desired/essential for survival and evolution.

Studies involving this concept (Raleigh) provide insight as to how bacteria has evolved to its current state, in terms of individual fitness and survival rate, as well as the process of sexual selection. Basically, it explains what it takes or has taken for certain bacteria to develop over time.

There have also been some studies (PhysOrg) that look into sexual selection as a precursor to conjugation, which would account for how bacteria have been able to evolve over time. While random conjugation does have the potential to be beneficial to bacteria, pickiness or manual selectivity in bacteria can prove to be beneficial as well, as a specific bacteria cell can have a specific trait that other bacteria cells don't which would be nice to have as a whole when considering the species' needs. While bacteria reproduce asexually in general, the “mates” they have been studied to have “chosen” over time have allowed them to produce offspring that are capable of survival. This is because the genes transferred through the bacteria plasmids are often genes that are likely to be beneficial for a bacteria cell.

This project takes primary form as a screenplay - a cautionary tale about a germ cell named Jeremy who, in an anomalous and biologically improbable (to say the least) way, seeks out other bacteria cells whose ornamental traits they fancy as opposed to the traits most bacteria seek out to survive and reproduce more efficiently. As bacteria generally do not possess any distinctive or diverse ornamental traits, the ones sought after by Jeremy are rather fictive as a way of indicating how unlikely/pointless ornamental selection would be (and is) in single-celled organisms. This story explains not only the reason(s) for why bacteria conjugate the way they do, but also how sexual selection can play a role in ultimately stimulating the rate and process of conjugation as a whole.

The animation included with the presentation part of the piece provides some visual insight that the script itself does not, such as the physical, visible process of conjugation. While the

characters in the script “discuss” conjugation in a similar way that young adults might discuss sex, the process is *drastically* different in virtually every way. I also wanted to showcase how similar the vast majority of bacteria are, and how the possibility of sexual selection in bacteria ultimately boils down to what minor genetic material one cell is able to transfer to another. Again, the script features some traits being shared that are unlikely to be as physically (visibly) significant (such as one character growing a flagellum and another being given the ability to thrive in a location it would not normally be able to if not for conjugation), but those are meant to emphasize and dramatize the importance of conjugation in bacterial species.

If it was at all possible to play this film for a crowded room of bacteria as a way to say “hey, make sure you don’t do this”, I would. However, not only is it unlikely that ANY bacteria at all practice improper forms of conjugation, but it’s just simply impossible to do that. As for the actual intended audience, I imagine the rather crude humor and overall nature in this story being somewhat of a tool used to connect with young adult audiences (say, 17-25 years old) who might likely be experiencing a time in their life when ornamental traits are paramount to them in their sexually selective tendencies. This story plays as somewhat of a cautionary tale warning the general public not to seek out solely ornamental traits in partners, but instead traits in partners that are beneficial in other ways, whether it be a charming personality or a protective physicality, etc. etc.

Annotated Bibliography

BD Authors. "Bacterial Conjugation" Biology Dictionary, May 18, 2017,

<https://biologydictionary.net/bacterial-conjugation/>

- This site has several biological references and terms, and provides a base definition and explanation of conjugation and its process. It's curated by several authors and is a good source to reference a good amount of general information regarding a wide range of topics of conjugation.

Maloy, Stanley R.. *Microbes and Evolution: The World That Darwin Never Saw*. ASM Press, 2012

- This book (available at the Pratt Library) provides several essays written by microbiologists about bacteria and its evolutionary history/process in regard to their knowledge of Darwin and the origin of species. This would help to better understand how bacteria itself has evolved and why conjugation came to exist.

Sapkota, Anupama. "Bacterial Conjugation - Definition, Principle, Process, Examples." Microbe Notes, May 2021,

<https://microbenotes.com/bacterial-conjugation/#examples-of-bacterial-conjugation>

- This site provides several examples of different types of conjugation that should be interesting to dig into and study. Understanding different types of conjugation could provide several explanations for why it exists and how it impacts different species of bacteria.

Kamiya, Anne. "Bacterial Conjugation: Definition and Process" Study.com, May 2022,

<https://study.com/learn/lesson/bacterial-conjugation-genetics-process.html>

- While I can't watch the video without making an account, this page begins to look at how and why bacteria meet up for conjugation, which could provide a beginning look into the sexual selection process of bacteria.

E.A. Raleigh, K.B.. "Bacterial Conjugation." Science Direct, 2019,
<https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/bacterial-conjugation>

- This page explores what causes bacterial conjugation to occur. It explains why it happens in the first place, and then also begins to explain the process of transferring genes in conjugation. This site also contains the work of several authors which will provide a lot of sources in one.

Kaiser, Gary. "Horizontal Gene Transfer in Bacteria." LibreTexts Biology,
[https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_\(Kaiser\)/Unit_2%3A_Bacterial_Genetics_and_the_Chemical_Control_of_Bacteria/3%3A_Bacterial_Genetics/3.1%3A_Horizontal_Gene_Transfer_in_Bacteria](https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Kaiser)/Unit_2%3A_Bacterial_Genetics_and_the_Chemical_Control_of_Bacteria/3%3A_Bacterial_Genetics/3.1%3A_Horizontal_Gene_Transfer_in_Bacteria)

- This page explores horizontal gene transfer in bacteria in depth. It also discusses the process of F⁺ and Hfr Conjugation, which are both essential in understanding the different kinds of conjugation bacteria undergo to reproduce and gather genetic data.

Cell Press. "The Argument For Sexual Selection in Bacteria" PhysOrg, September 2019
<https://phys.org/news/2019-09-argument-sexual-bacteria.html#:~:text=Sexual%20selection%20can%20sometimes%20result%20in%20coercion%20where,that%20prime%20other%20bacteria%20to%20take%20up%20DNA.>

- As the title suggests, the article above explores the concept of sexual selection in Bacteria, and how that can be understood. In understanding the process of bacteria's version of sexual "selection", I can better understand what kind of bacteria is "sought after" for their genetic data and why.

Neil, Kevin. "Molecular Mechanisms Influencing Bacterial Conjugation in the Intestinal Microbiota." PubMed Central, June 2021,
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8213034/>

- This article goes into a study in which an experiment aimed to instigate bacterial conjugation took place. The results and process of this experiment could help to understand better what conditions could influence conjugation, and in what cases the bacteria might stray away from the genetic transfer process.

Frankel, Gad. "Plasmids pick a bacterial partner before committing to conjugation" Oxford Academic, August 2023, <https://academic.oup.com/nar/article/51/17/8925/7244778?login=false>

- This recent source goes into detail what role plasmids play in the conjugation of bacteria. It goes into a lot of detail about different parts of bacteria's anatomy like the TraN Sensors and OMP's and how they allow bacteria to conjugate, which could be helpful in understanding what conjugation might look like visually.

Ryding, Sara. "Structure and Role of Pili in Prokaryotes." News Medical, October, 2018, <https://www.news-medical.net/life-sciences/Structure-and-Role-of-Pili-in-Prokaryotes.aspx>

- Similar to the last source, this article explains the structure of bacteria and how its anatomy influences the process of conjugation, which is nice to know because it's important to understand how the physical evolution of said bacteria allows the conjugation process to be carried out.

GEREMY: A MICROSCOPIC CAUTIONARY TALE

Written by

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EXT. LEFT KNUCKLE CENTRAL - EVENING

It's a busy day on the top of a human hand - three bacterial cells weave their way through a large crowd of other bacteria, deep in conversation.

BACILLUS, a rod-shaped bacteria cell, nudges COCCUS, a small, spherical cell, getting his attention. Bacillus points at a nearby CRAZY CELL holding a sign jumping frantically in a small opening in the crowd.

CRAZY CELL
THE FLOOD IS COMING!!! OH GOD OH NO
IT'S COMING AND YOU ARE ALL TOO
BLIND TO SEE IT!! OH GOD!!!!

BACILLUS
(scoffs)
Get a load of this guy.

LEPPY, a zoned-out looking spiral shaped cell looks ahead of the crowd. Something catches its gaze.

LEPPY
Yo, hold up - is that Jeremy?

GEREMY, a larger sphere-shaped cell with a bluish tint makes their way through the crowd to the other three cells. There's something smug about the way Jeremy approaches them as they raise their "arms" in greeting.

GEREMY
Leppy! Coccus! Bacillus, what's up
y'all!

BACILLUS
Jeremy! You're looking well.

Jeremy doesn't respond, instead maintaining eye contact with Bacillus, waiting for them to continue.

BACILLUS (CONT'D)
A little... uh... bluer.

GEREMY
(interrupting)
BLUER, yeah, I know. Looks good
right? I got with this GOOORGEOUS
Anaerobe from the Gastro-tract down
south. I saw them and was like "OH
I gotta have that!"

Jeremy's excitable mannerisms while telling this story is met with unimpressed silence from their friends as they stare back at them.

LEPPY

So, uh... what else did you get?

Jeremy stares back inquisitively.

GEREMY

Whaddaya mean?

LEPPY

Like, what else did you get from the Anaerobe? Can you, like, infect teeth now or something?

GEREMY

I'm not following.

BACILLUS

Dude, come on. Don't tell me you just got a stupid color from them.

Jeremy looks down shyly, maybe a little embarrassed.

GEREMY

But I like blue.

LEPPY

Yeah man, everybody likes blue.

COCCUS

Yeah, everyone.

BACILLUS

Blue is a bangin' color man, no doubt. But if you're really gonna put *that* much thought into who you're conjugating with you might as well try to get... something useful out of it.

LEPPY

Yeah, like a couple minutes ago, I got with this Mesophile that I was infecting the body with. Before I met them I couldn't go *anywhere* under 70 degrees Celsius, and now here I am with you guys.

COCCUS

I don't even really care who I get
with. I just play the field, ya
know? What happens, happens.

Coccus gives Leppy a fist bump and Bacillus turns to Jeremy.

BACILLUS

I had a buddy who got this gene
that lets them replicate faster
without as much energy. I dunno how
they managed to get so lucky with
that but I guarantee you we're
surrounded by, like, at least 4,000
of that guy right now.

The Crazy Cell holding the sign gets closer to them and yells
louder about the impending flood.

BACILLUS (CONT'D)

And if that dude is right then at
least one of them has to make it
out alive.

Jeremy rolls their nonexistent eyes.

GEREMY

Yeah, right. Last flood was six
hours ago. I highly doubt there's
another one coming any time soon.

Coccus' face contorts as another version of them quickly
spawns at their side and detaches from them. The two
identical cells stare at each other for an awkward moment,
nod at each other, and the copy walks off.

COCCUS

(to the others)

Sorry you guys had to see that.
Couldn't hold it any longer.

The other two cells keep looking at Jeremy judgingly.

GEREMY

Come on, you guys, this isn't two
weeks ago. SOR-RY if I want to have
a little fun with who I'm
conjugating with.

Leppy shakes their head as they and Coccus walk off. Bacillus
stays behind for a moment and places their "hand" on Jeremy's
"shoulder".

BACILLUS

I'm glad you're putting yourself
back out there after the incident.
Just please, for me... for us...
make sure you're doing it for the
right reason.

Bacillus follows after Leppy and Coccus, leaving Jeremy alone among the crowd.

Jeremy scowls and turns around. Their gaze is caught by a nearby cell whose pili (hair-like appendages on bacteria) is thick and wavy. Jeremy raises an "eyebrow" and saunters over to it.

INT. HUMAN HAND "CAVES" - THE NEXT FEW HOURS

We see Jeremy conjugate with a large number of different cells. As they finalize the gene transfer process, Jeremy gains the ornamental traits the other cells possess (unique capsule patterns, cytoplasm glossiness, etc.)

At the same time, the other cells acquire traits of Jeremy's that are significantly more valuable from a survival standpoint (anti-bacterial product immunity, more efficient ribosomal structure, etc.)

After conjugating with all these bacteria, Jeremy looks at himself in the mirror. They're nearly unidentifiable from when we first saw them.

Jeremy's face contorts. Through a similar process Coccus experienced, a copy of Jeremy is created and detaches from them. The two stare at each other.

Initially, they're jealous of each other's looks. But then their harsh gaze softens.

If there's two of them...

That means more conjugation! More trait acquiring!

The two Jeremy cells go their separate ways and continue conjugating with any cell carrying an ornamental characteristic they can.

As they continue their process, they replicate, and then those cells replicate, and so on and so on.

EXT. LEFT KNUCKLE CENTRAL - A FEW HOURS LATER

Bacillus and Leppy sit at a bench, surrounded by an overwhelming number of Jeremy-like bacteria. They scan the crowd looking for Coccus, who eventually comes flying in from the air, landing next to them.

Coccus, who now has a more advanced, larger flagellum allowing easier and more efficient movement, does a little twirl showcasing their new trait.

COCCUS

Sorry I'm late fellas, I was a little busy.

BACILLUS

Man, I can tell! Nice flagellum, bro! I bet you can get anywhere with that thing!

Leppy, ignoring the two, looks around at all the Jeremys.

LEPPY

Well it doesn't seem like you're the *only* one who's been busy.

As the Jeremys continue to walk around, they replicate almost without even knowing it.

BACILLUS

Well, hey, at least there's a lot of them, you know? More chances to conjugate and reproduce and... stuff.

LEPPY

Yeah, well, If they ain't careful they're gonna start conjugating with each other.

A Jeremy clone jogs over to the three, grinning widely.

GEREMY

Wassup guys! What do we think?

Coccus looks Jeremy up and down.

COCCUS

Yeah, you look good, bro. I'd conjugate.

(awkward beat)

If there was literally anything of value.

GEREMY

Alright, tail-boy, good one. Y'all are really *still* hung up over that "value" stuff? It isn't like I'm giving anything up - the best parts of me are still here, baby!

Coccus looks down insecurely at their new flagellum. Leppy looks away at all the other Geremys walking around them.

BACILLUS

You're starting to look ridiculous, bro.

GEREMY

I look fantastic, you're trippin'.

Bacillus stands up, walks over to Geremy, and shoves them to the ground, creating a crack in Geremy's cell wall as cytoplasm oozes out.

Startled and hurt, Geremy looks at Bacillus with hostility.

BACILLUS

See, if you had Coccus' "tail" you'd have been able to avoid that.
(acknowledging crack)
And if you conjugated with somebody for their cell wall structure, that wouldn't have happened either. But congrats on your sparkly cytoplasm. Really suits you.

Geremy tries to get up but it hurts too much. They let out a pained chuckle.

GEREMY

(strained)

All this just 'cause you're jealous I'm getting with more bacteria than you.

Leppy walks over and stares down at Geremy.

LEPPY

It isn't about how many you get with, Brah. It's *why* you conjugate with them. That's what really matters.

Coccus hobbles over and stares down at him too.

Geremy starts to say something but is cut off by the Crazy Cell shouting in the near proximity.

CRAZY CELL
NOOOOOOOO OH GOD WHYYYYYYYYY!!!! I
TOLD YOU! I TOLD YOU ALL!! THE
FLOOD IS HERE FOR US.

Jeremy, Bacillus, Leppy, and Coccus look to the sky as an enormous faucet fills their view, a gigantic soap dispenser emerging next to it.

Screams gradually fill the area as cells topple over each other, sprinting from the incoming, foamy soap raining from above.

The soap stops falling after creating a large mountain on the hand what seems like a far distance from the cells. The cells around the group continue running away. Jeremy and their friends stand motionless, staring at the soap mountain.

LEPPY
Well, that wasn't so terri -

Before Leppy can finish another hand enters their line of sight and turns the faucet on. A much more aggressive, powerful stream of water explodes onto the surface of the hand, destroying the cells that it reaches.

Coccus flies away from the flood, avoiding soap-filled droplets flying towards them.

Leppy crouches behind a crevice in the hand and latches onto the ground with their pili, keeping them locked on as the water cascades over them.

It's a chaotic, gruesome scene as the billions of bacteria cells inhabiting Human Hand Central are disintegrated, bashed, and poisoned by the soapy water that surrounds them.

CUT TO BLACK:

EXT. HUMAN HAND CENTRAL - MINUTES LATER

The remaining cells from the disaster slowly congregate with one another, making sure everyone is alright.

Bacillus lays motionless on the surface of the hand. Coccus and Leppy jog over to them, shaking them.

COCCUS
Bacillus?? Bacillus, you okay?

Bacillus comes to, choking up water. After taking a few breaths, they slowly stand up, leaning on Coccus and Leppy for support.

COCCUS (CONT'D)

How are you alive?? I was sure we
lost you!

Bacillus points to a small, glowing strand of DNA in their
body.

BACILLUS

Disinfectant immunity gene. Picked
it up from some cell at the bar the
other night. Figured it might come
in handy.

LEPPY

Well, as always Bac, you were
right.

The three look among the 0.01% Of bacteria cells remaining
amongst the vast human hand, which was once jam-packed with
other bacteria. Not a single Jeremy clone can be seen.

LEPPY (CONT'D)

Can't say the same for Jeremy.

The two continue walking down the human hand, engaging in
conversation.

BACILLUS

You know, I'm really gonna miss
that cell.

LEPPY

No you aren't.

BACILLUS

No, I'm not. They were *so* annoying.

COCCUS

Remember Kary's party a few hours
ago? How wasted they got?

LEPPY

Jeez, don't get me started.

Beat.

COCCUS

So, uh... Bacillus. That
disinfectant immunity trait... You
think I could...?

BACILLUS

(blushing)

Only if you share that flagellum
with me, bro.

COCCUS

Nah, flagellum is mine, I'm saving
that for some-cell special. I can
give you a dexterity gene or two if
you want.

BACILLUS

Sold.

LEPPY

I can make your pili a little
thicker if you want.

BACILLUS

Why don't you say us three just get
on with it and figure it out as we
go along?

The three laugh and continue walking into the distance.

END