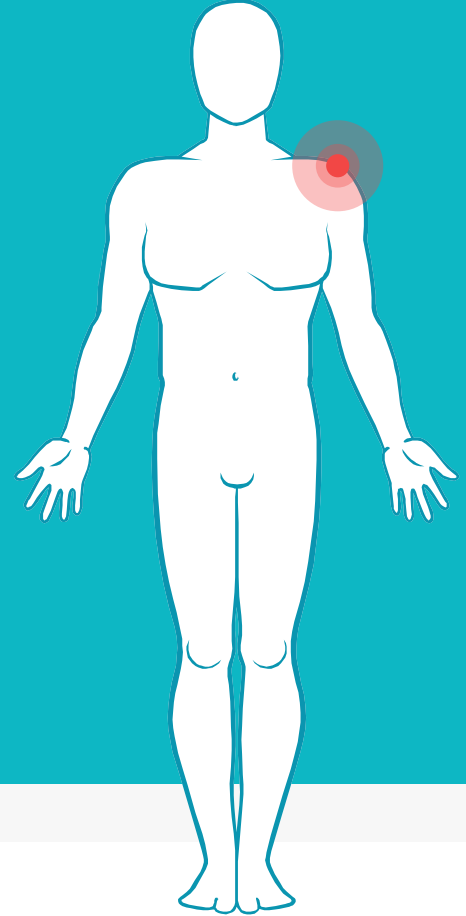


# Precision Cancer Medicine: A SMART Web App



Makiah Bennett & Jack Flahive



Dave Coverly

"I GAVE IT A HEALTHY DOSE OF DENIAL,  
BUT IT DIDN'T HELP."

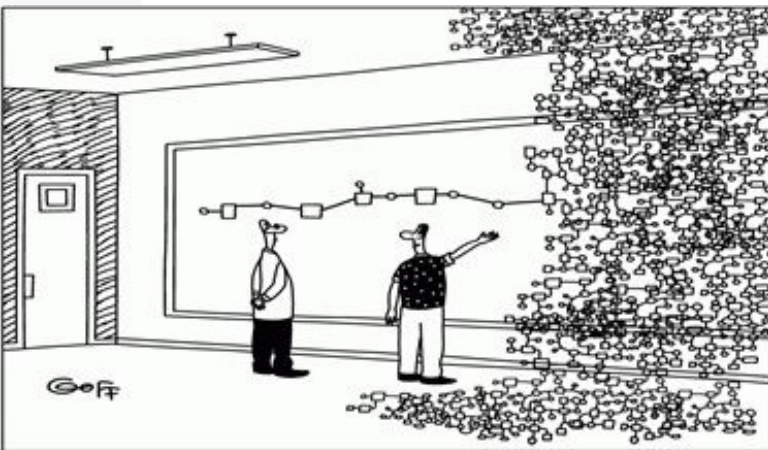
# Motivations

Why bother?

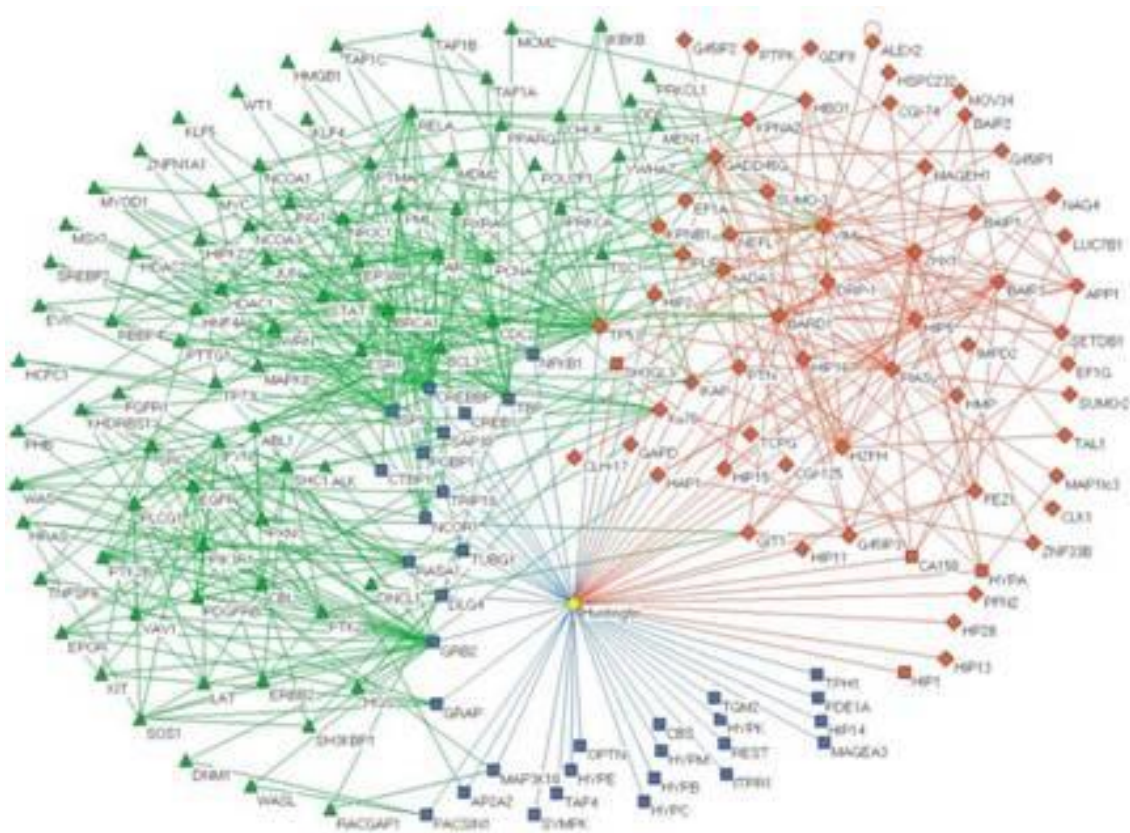




# Second Motivation: EHRs Overly Complex



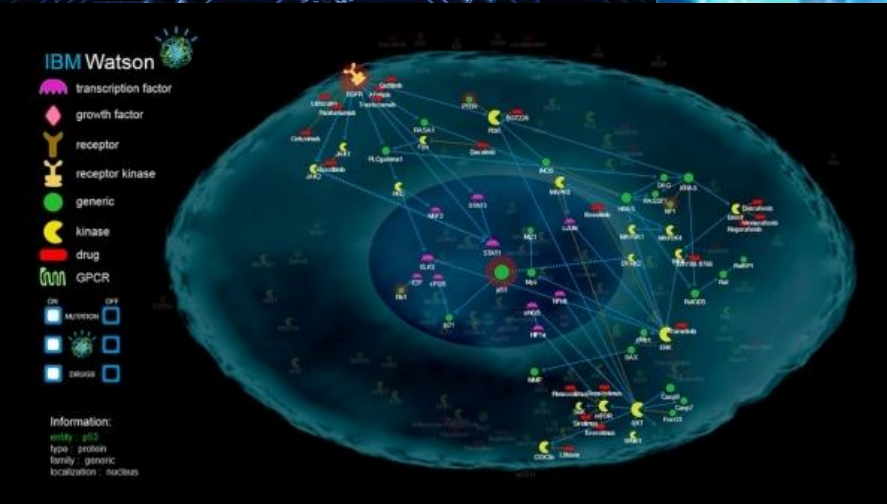
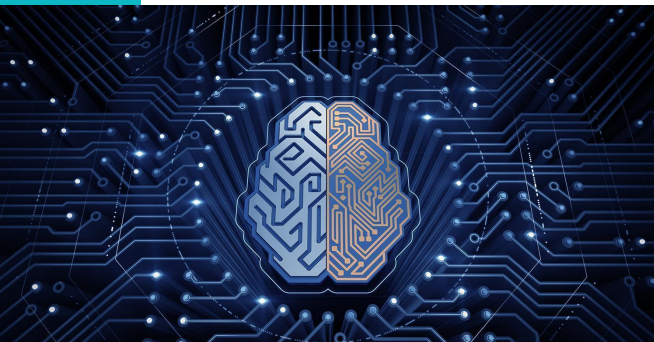
*"This is where the idea for the new EHR starts getting a little complicated."*







# Third Motivation: AI



# Background

Prerequisites to understanding the app.

# Precision Medicine

*An emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person.*



”

*-NIH (National Institutes of Health)*



# The Precision Cancer Medicine Initiative

*“Doctors have always recognized that every patient is unique, and doctors have always tried to tailor their treatments as best they can to individuals. You can match a blood transfusion to a blood type — that was an important discovery. What if matching a cancer cure to our genetic code was just as easy, just as standard? What if figuring out the right dose of medicine was as simple as taking our temperature?”*

”

- President Obama, 2015





*FHIR aims to simplify implementation without sacrificing information integrity. It leverages existing logical and theoretical models to provide a consistent, easy to implement, and rigorous mechanism for exchanging data between healthcare applications.*





*[..] a set of **open specifications** to integrate apps with Electronic Health Records, portals, Health Information Exchanges, and other Health IT systems.*

”

- [docs.smarthealthit.org](https://docs.smarthealthit.org)



*[...] an open-source implementation of the FHIR specification in Java.*

”

- *hapifhir.io*

# Development

In progress!

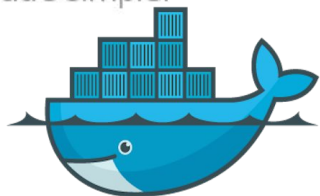




# The S4G2 Server Backend

 `<Hapi />` HAPI-FHIR  
fhir made simple.

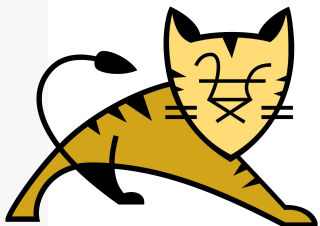
RESTful API  
GET PUT POST DELETE



docker



on



```

* Debugger pin code: 818-054-806
Sat May 20 22:51:56.543 [initandlisten] preallocateIsFaster=true 12.3
Sat May 20 22:51:56.543 [initandlisten] preallocateIsFaster check took 6.923 secs
Sat May 20 22:51:56.544 [initandlisten] preallocating a journal file /data/db/journal/prealloc.0
Sat May 20 22:51:59.923 [initandlisten] File Preallocator Progress: 524288000/1073741824 48%
Sat May 20 22:52:02.009 [initandlisten] File Preallocator Progress: 838860000/1073741824 78%
Sat May 20 22:52:06.661 [initandlisten] File Preallocator Progress: 943718400/1073741824 87%
Sat May 20 22:52:10.295 [initandlisten] File Preallocator Progress: 985661440/1073741824 91%
Sat May 20 22:52:14.519 [initandlisten] preallocating a journal file /data/db/journal/prealloc.1
Sat May 20 22:52:17.787 [initandlisten] File Preallocator Progress: 503316480/1073741824 46%
Opening data file and reading scopes
Sat May 20 22:52:20.894 [initandlisten] File Preallocator Progress: 765460480/1073741824 71%
Sat May 20 22:52:25.900 [initandlisten] File Preallocator Progress: 922746880/1073741824 85%
Attempting to load a scope...
Sat May 20 22:52:35.101 [initandlisten] preallocating a journal file /data/db/journal/prealloc.2
Sat May 20 22:52:38.060 [initandlisten] File Preallocator Progress: 524288000/1073741824 48%
Sat May 20 22:52:41.571 [initandlisten] File Preallocator Progress: 796917760/1073741824 74%
Sat May 20 22:52:45.969 [initandlisten] File Preallocator Progress: 975175680/1073741824 90%
Sat May 20 22:52:53.133 [FileAllocator] allocating new datafile /data/db/local.ns, filling with zeroes...
Sat May 20 22:52:53.133 [FileAllocator] creating directory /data/db/.tmp
Sat May 20 22:52:53.163 [FileAllocator] done allocating datafile /data/db/local.ns, size: 16MB, took 0.014 secs
Sat May 20 22:52:53.181 [FileAllocator] allocating new datafile /data/db/local.0, filling with zeroes...
Sat May 20 22:52:53.208 [FileAllocator] done allocating datafile /data/db/local.0, size: 64MB, took 0.026 secs
Sat May 20 22:52:53.225 [webservr] admin web console waiting for connections on port 28017
Sat May 20 22:52:53.261 [initandlisten] waiting for connections on port 27017
Sat May 20 22:52:53.600 [FileAllocator] allocating new datafile /data/db/s4gserver.ns, filling with zeroes...
Sat May 20 22:52:53.676 [FileAllocator] done allocating datafile /data/db/s4gserver.ns, size: 16MB, took 0.075 secs
Sat May 20 22:52:53.696 [FileAllocator] allocating new datafile /data/db/s4gserver.0, filling with zeroes...
Sat May 20 22:52:53.715 [FileAllocator] done allocating datafile /data/db/s4gserver.0, size: 64MB, took 0.018 secs
Sat May 20 22:52:53.716 [FileAllocator] allocating new datafile /data/db/s4gserver.1, filling with zeroes...
Sat May 20 22:52:53.716 [conn2] build index s4gserver.scopes { _id: 1 }
Sat May 20 22:52:53.722 [conn2] build index done. scanned 0 total records. 0.005 secs
Sat May 20 22:52:53.723 [conn2] insert s4gserver.scopes ninserted:1 keyUpdates:0 locks(micros) w:122589 122ms
Successfully loaded a scope!!

Attempting to load a scope...
Sat May 20 22:52:53.737 [FileAllocator] done allocating datafile /data/db/s4gserver.1, size: 128MB, took 0.02 secs
Successfully loaded a scope!!

```

```

Starting S4G2 server...
npm info it worked if it ends with ok
npm info using npm@4.2.0
npm info using node@v7.10.0
npm info lifecycle s4gserver@1.0.0-prestart: s4gserver@1.0.0
npm info lifecycle s4gserver@1.0.0-start: s4gserver@1.0.0

```

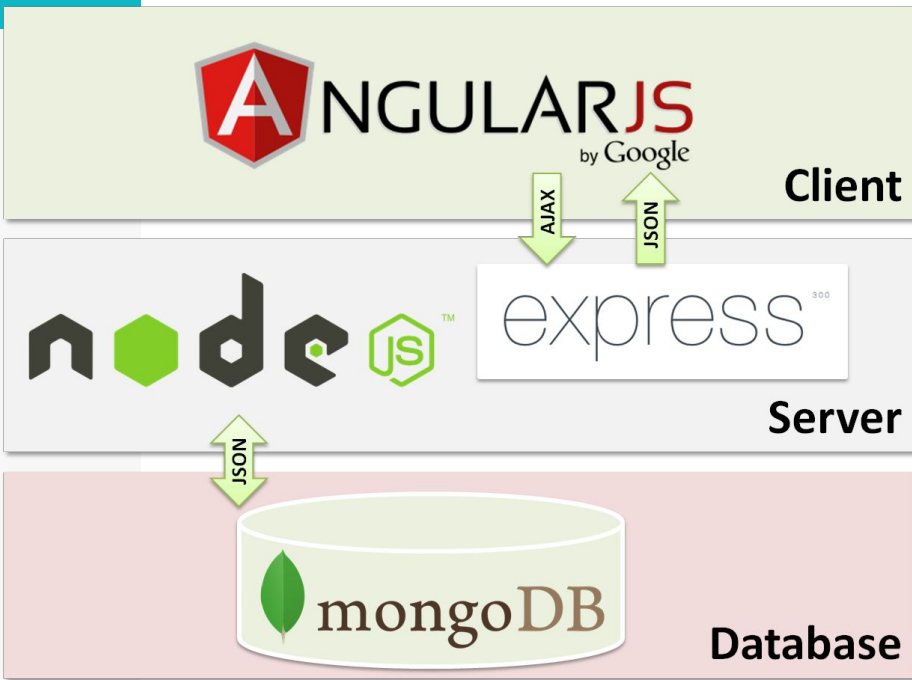
```

> s4gserver@1.0.0 start /root/s4gserver
> node ./bin/www

```

express-session deprecated undefined resave option; provide resave option app.js:35:9  
express-session deprecated undefined saveUninitialized option; provide saveUninitialized option app.js:35:9

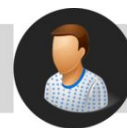
# The Front-End



Fitzgerald, Dean

## Mutations

Name	Variant
AURKA	E4499K
CCND1	V2037F
CHEK2	R156P
EWSR1	loss
FOXP1	R1031Q
GID4	F171fs*3
TP53	Amplification
JAK2	D423E
CDKN1B	Amplification



Trump, Donald



DeVos, Betsy



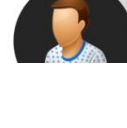
Pence, Michael



Schmoe, Joe



Biden, Joe



Obama, Barack

Those here are grouped in order of their similarity to their genome's mutations.

```
var server = app.listen(process.env.PORT || 8080, "0.0.0.0", function ()  
{  
  console.log('Server listening at http://' + server.address().address + ':' + server.address().port);  
});
```



**John Smith**

Gender: M  
DOB: 24 June 1990  
Height: 182 cm

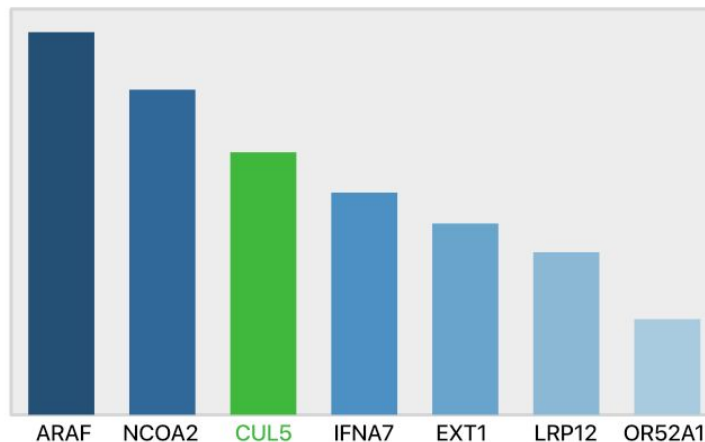
**Predictions**

[Comparisons](#)

[Wiki](#)

[Settings](#)

## Potential Driver Genes



\*Genes will be ranked by a SMART-PCM Score

## Currently Viewing:

Gene	Driver	PCM Score	Mutation			Drug
			Mut. Syntax	Category	Prot. Syntax	
<a href="#">CUL5</a>	Yes	0.73	<a href="#">c.T1630G</a>	point coding	p.F544V	<a href="#">AT-406</a>

## Go To:

[Full Data](#) | [Top 50 Genes](#) | [Drugs](#)

# Alternate View



**John Smith**

Gender: M  
DOB: 24 June 1990  
Height: 182 cm

Mutations

Comparisons

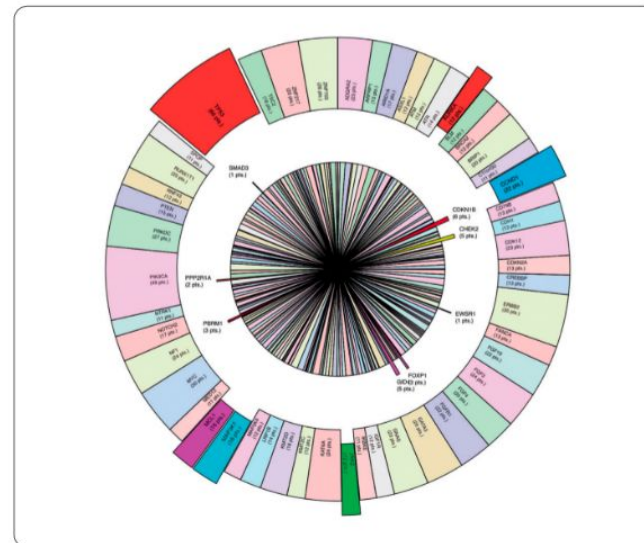
Wiki

Settings

## Mutations

Name	Variant
AURKA	E4499K
CCND1	V2037F
CHEK2	R156P
EWSR1	loss
FOXP1	R1031Q
GID4	F171fs*3
TP53	Amplification
JAK2	D423E
CDKN1B	Amplification

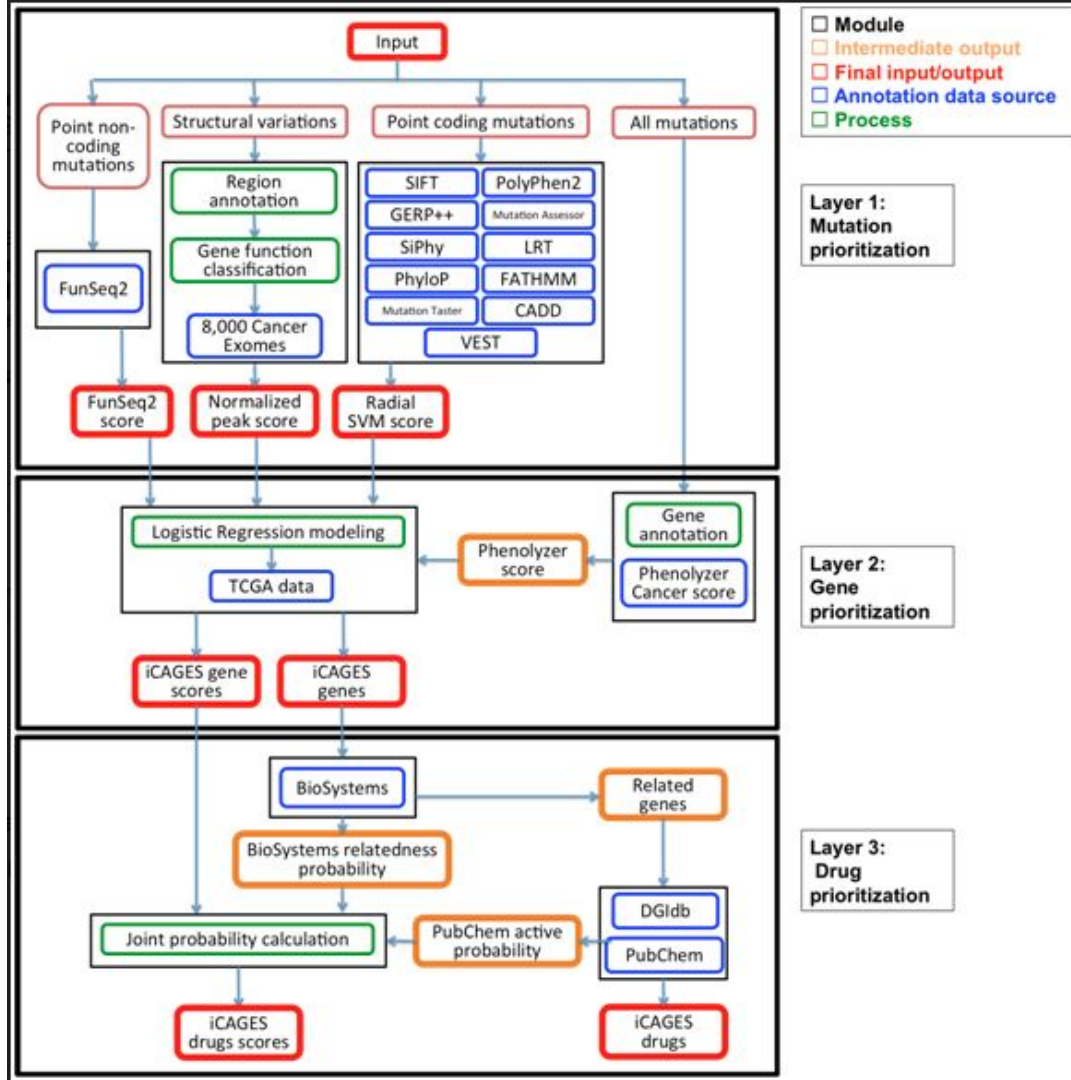
## Mutated Genes Observed in Breast





# Convolution

- ▷ 3 Main Layers
  - ▶ Layer 1: Prioritizes cancer “driver” mutations.
  - ▶ Layer 2: Links mutations to genes using logistic regression.
  - ▶ Layer 3: Generates a prioritized list of drugs targeting driver genes.
- ▷ Similar to the iCAGES pipeline.





# Appendix

- ▷ Electronic Health Record (EHR)
  - ▶ Electronic version of a patient's medical history
- ▷ Substitutable Medical Applications and Reusable Technology (SMART) Health IT Platform
  - ▶ Open access API that classifies and packages genomic information for use in clinical applications
  - ▶ Allows for the integration of different data types in one application
- ▷ Fast Healthcare Interoperability Resources (FHIR)
  - ▶ Standard for exchanging healthcare information electronically
- ▷ Single Nucleotide Polymorphisms (SNPs)
  - ▶ The variation of a single base pair in a DNA sequence
- ▷ VCF Files
  - ▶ “Variant Call Format”: the raw file data format which our database provides for parsing. Used in the Texas patient database to which we refer for data.

# Acknowledgements

- ▶ Thank you to Dr. Alterovitz for the much-needed help and support and the project idea!
- ▶ Thank you to Maksym Korablyov for answering and continuing to answer our many questions on machine learning!
- ▶ Thank you to MIT PRIMES for the enjoyable and interesting research opportunity!

# THANKS!

## **Any questions?**

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- ▶ [jack.flahive@gmail.com](mailto:jack.flahive@gmail.com)