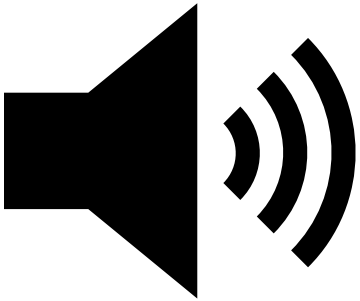
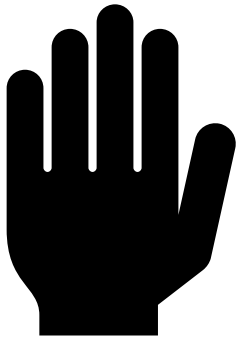
See elegance in a worm brain

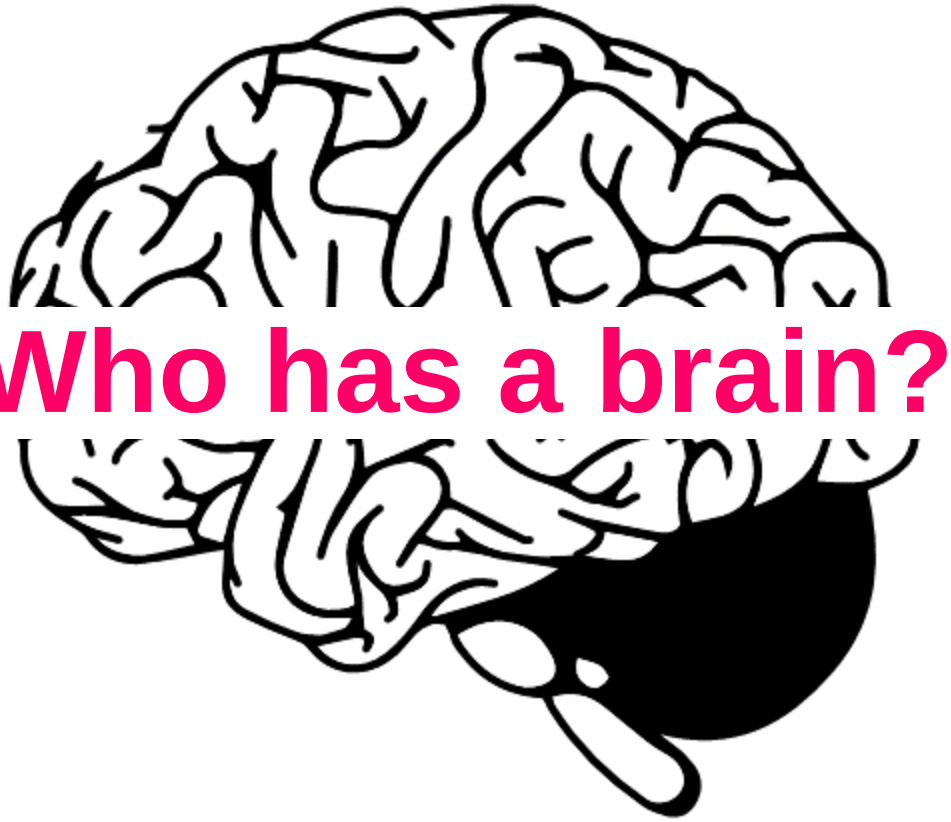
Designated assistant professor
Graduate school of Science, Nagoya University
Ken Noma

Volume



STOP!





Who has a brain?


Wonderful!!

Today's menu

- Appetizer -

Brain

- Main dish -

Worm

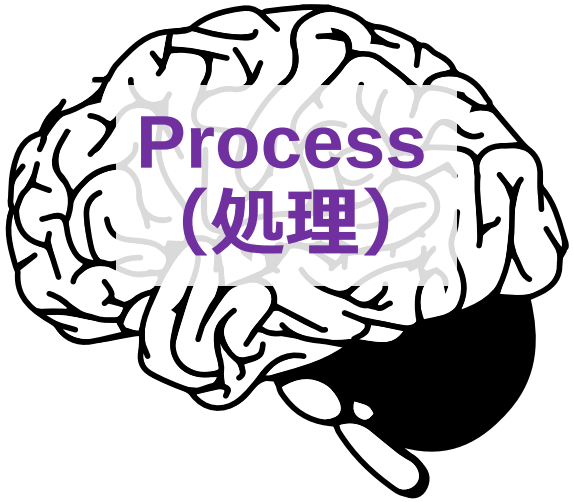
8 elegant things

- Dessert -

Me

The brain is

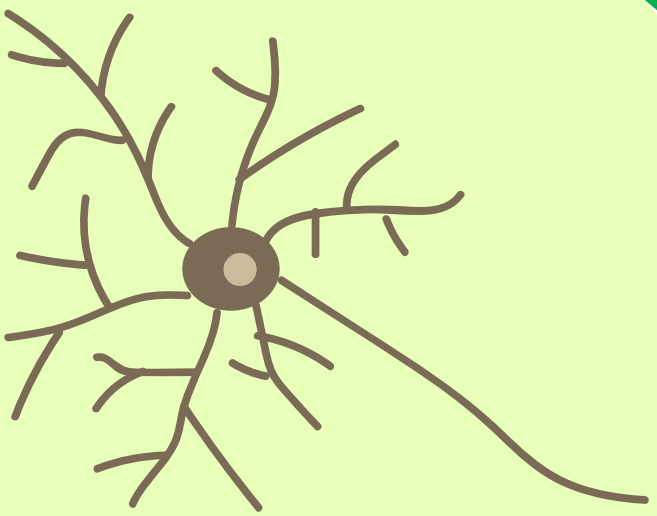
Input



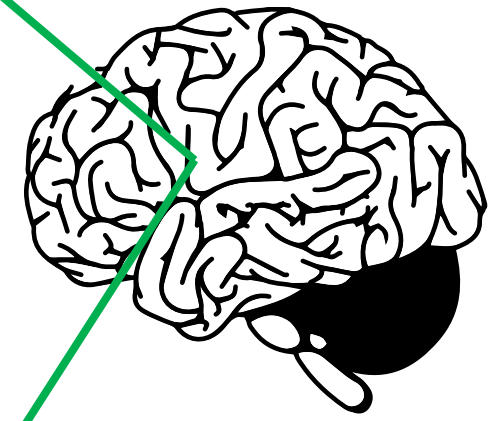
Output

the organ inside the head that controls thought, memory, feelings, and activity. (Cambridge dictionary)

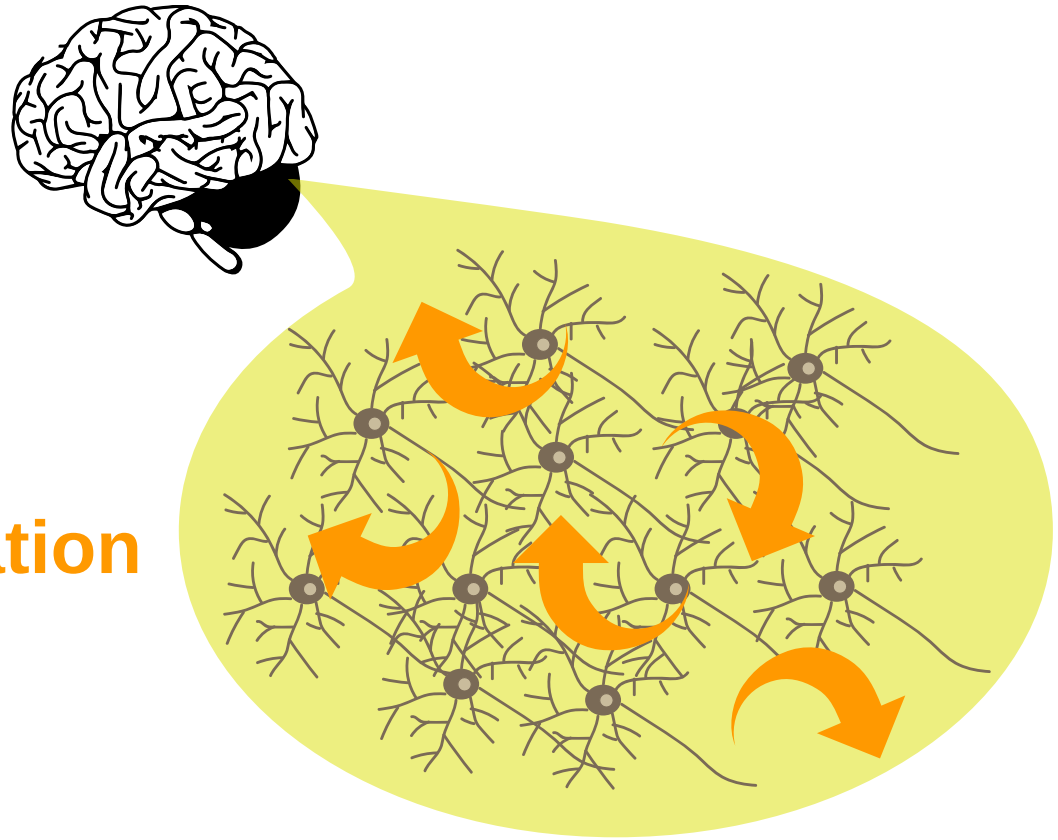
Neurons are the functional units of the brain



Neuron 神経細胞
(a type of the cell)



Neurons communicate with each other to process information



Communication

Exciting questions about the brain

How do neurons process information?
処理する

How is the brain formed?

What is the consciousness?
意識


The problem
Our brain is too complex

Quiz
How many neurons in our brain?

1. 1000 (thousand)

2. 1000,000 (million)

3. 1000,000,000 (billion)

Quiz
How many neurons in our brain?

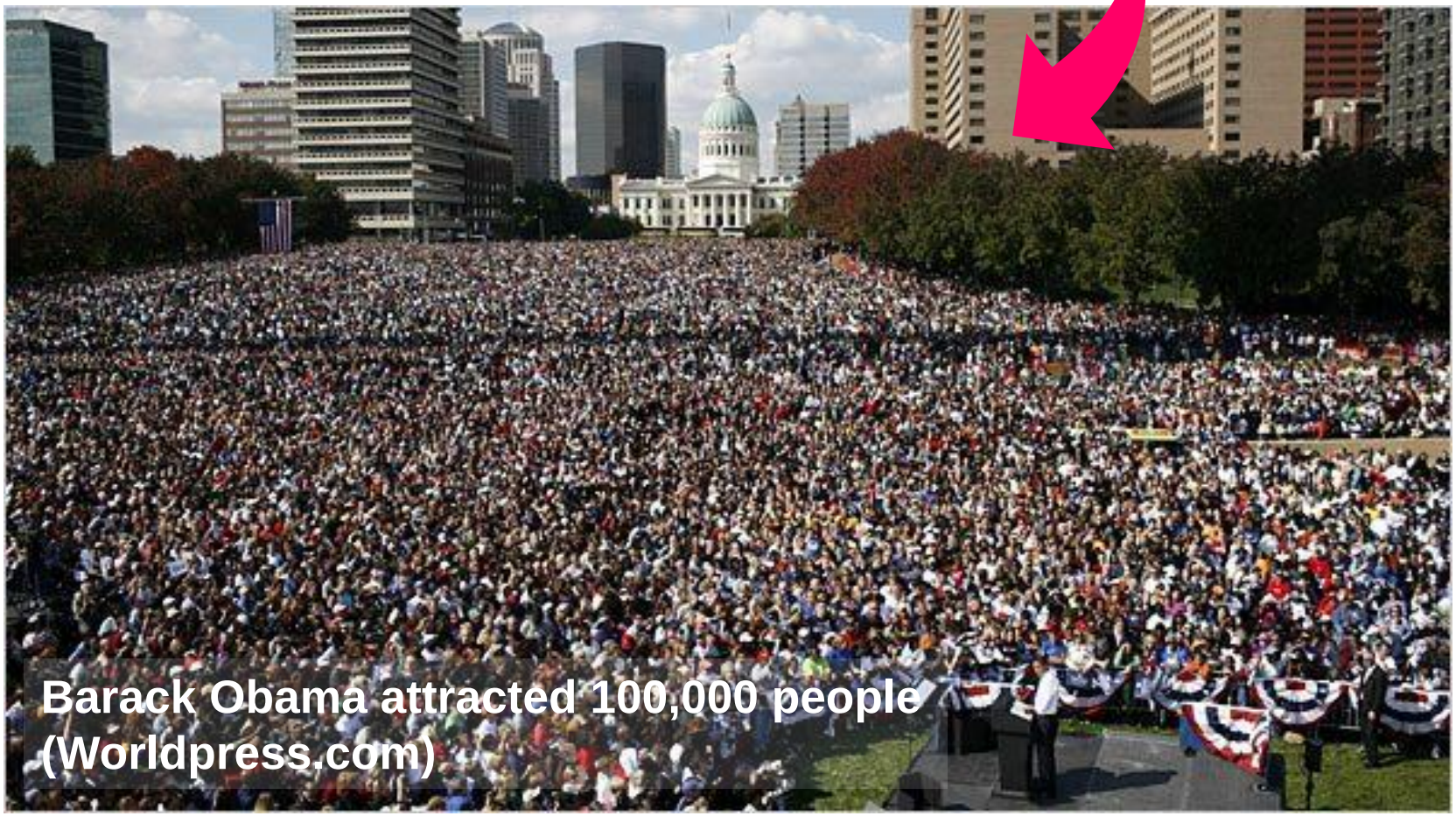
1. 1000 (thousand)

2. 1000,000 (million)

3. 1000,000,000 (billion)

4. 100,000,000,000 (100 billion)

1,000,000 times this




That’s…
too…
complicated…
by Chip Somodevilla/Getty.

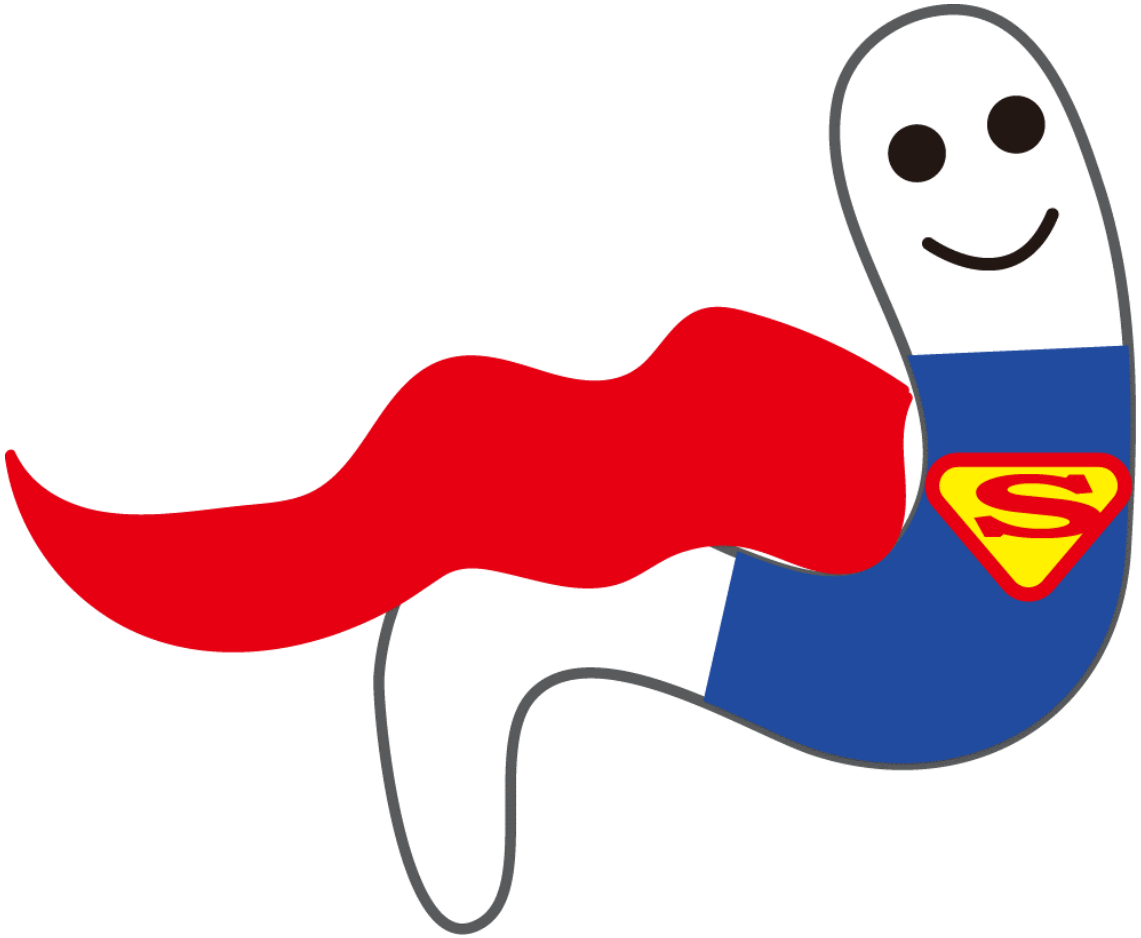
Problems of the human brain as a research subject

Human brain is

1. too complicated 
2. hard to see 
3. hard to manipulate 

What should we do?

Worm the hero



Today's menu

- Appetizer -

Brain

- Main dish -

Worm

- Dessert -

Me

The worm

Caenorhabdits elegans (C. elegans)

Model organism

Simple and easy!!

➡ **Core principle** ➡

原理

The worm

Caenorhabdits elegans (C. elegans)

by nobelprize.org

1974

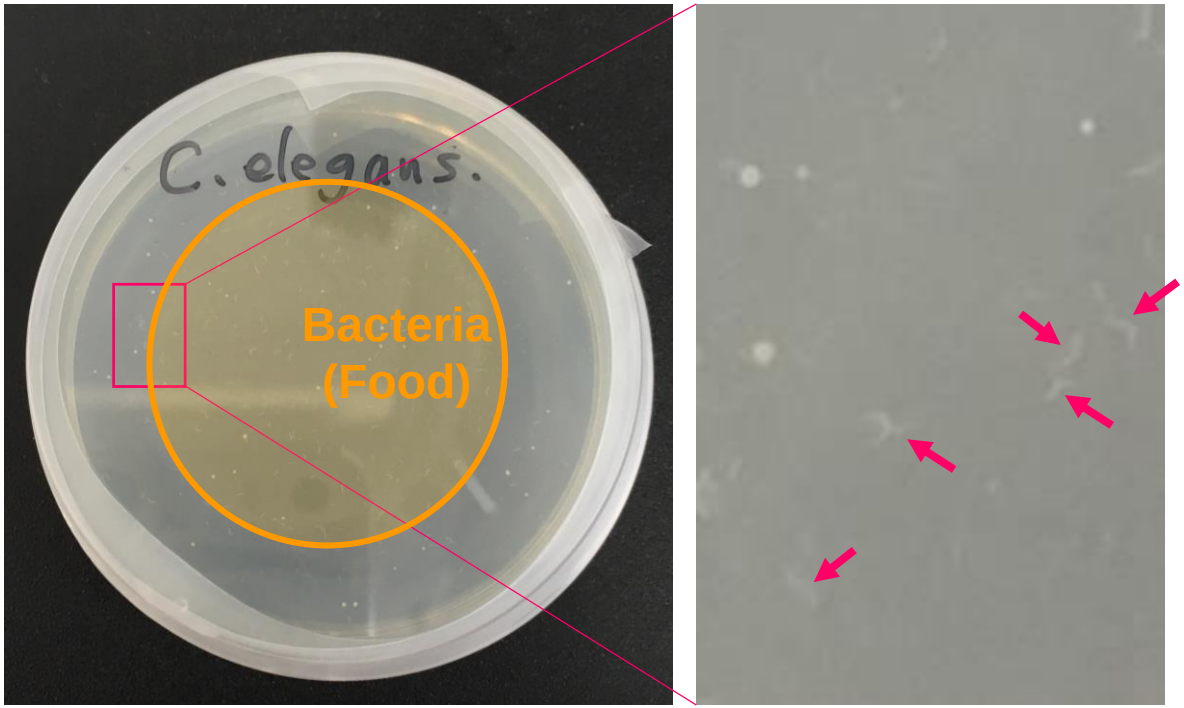
THE GENETICS OF *CAENORHABDITIS ELEGANS*

S. BRENNER

Medical Research Council Laboratory of Molecular Biology, Hills Road, Cambridge, CB2 2QH, England

Nobel prize in 2002

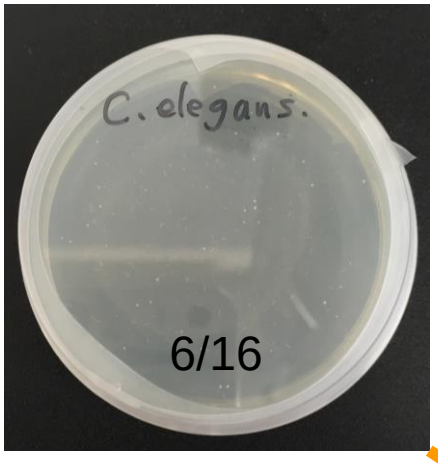
You are going to receive this



C. elegans is **NOT** parasitic **NOR** harmful.

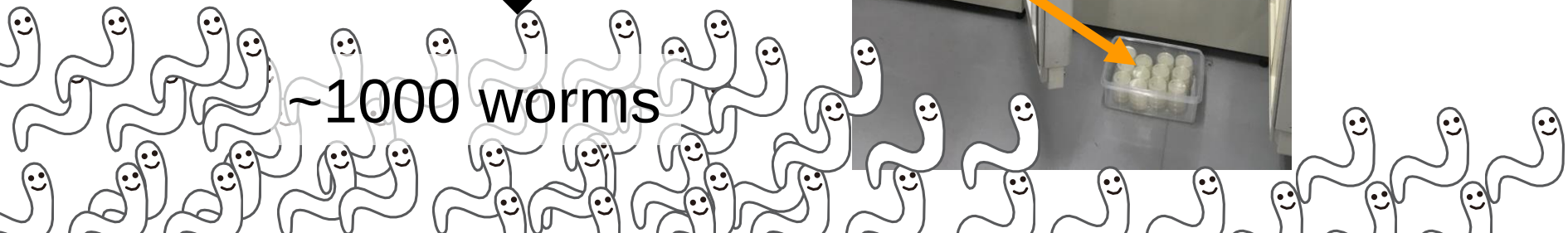
寄生性

Elegance 1
C. elegans is easily maintained
（飼育）



Hermaphrodite
雌雄同体

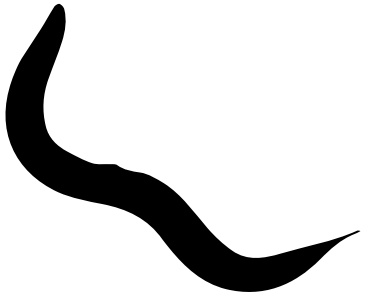
3 days



The worm show

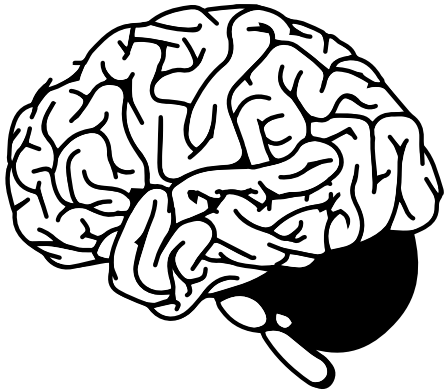
Elegance 2
C. elegans senses and responds to stimuli
（刺激）

Touch



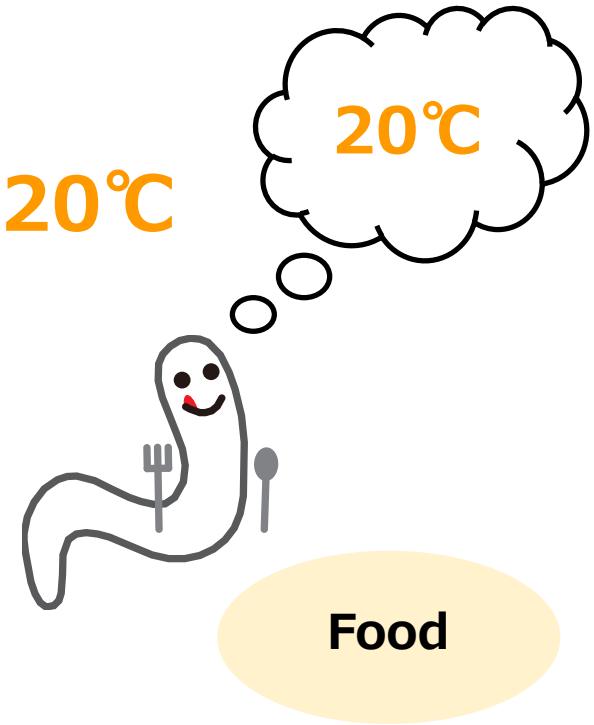
Movement

Input

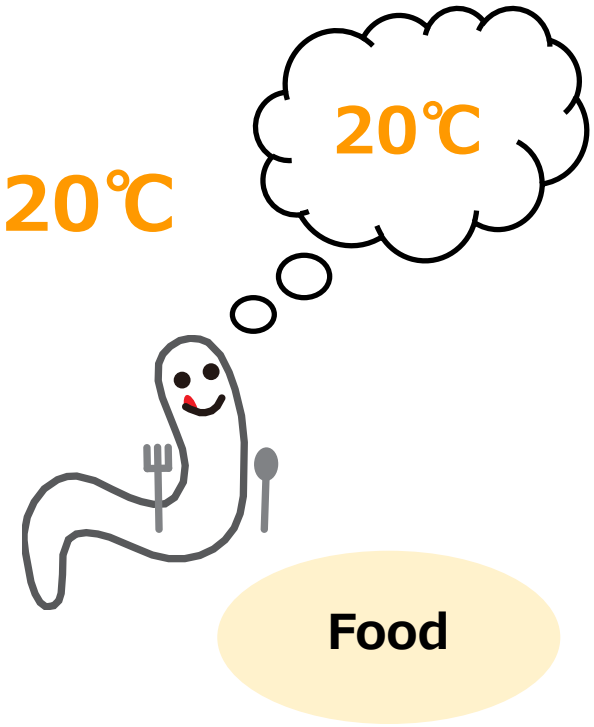


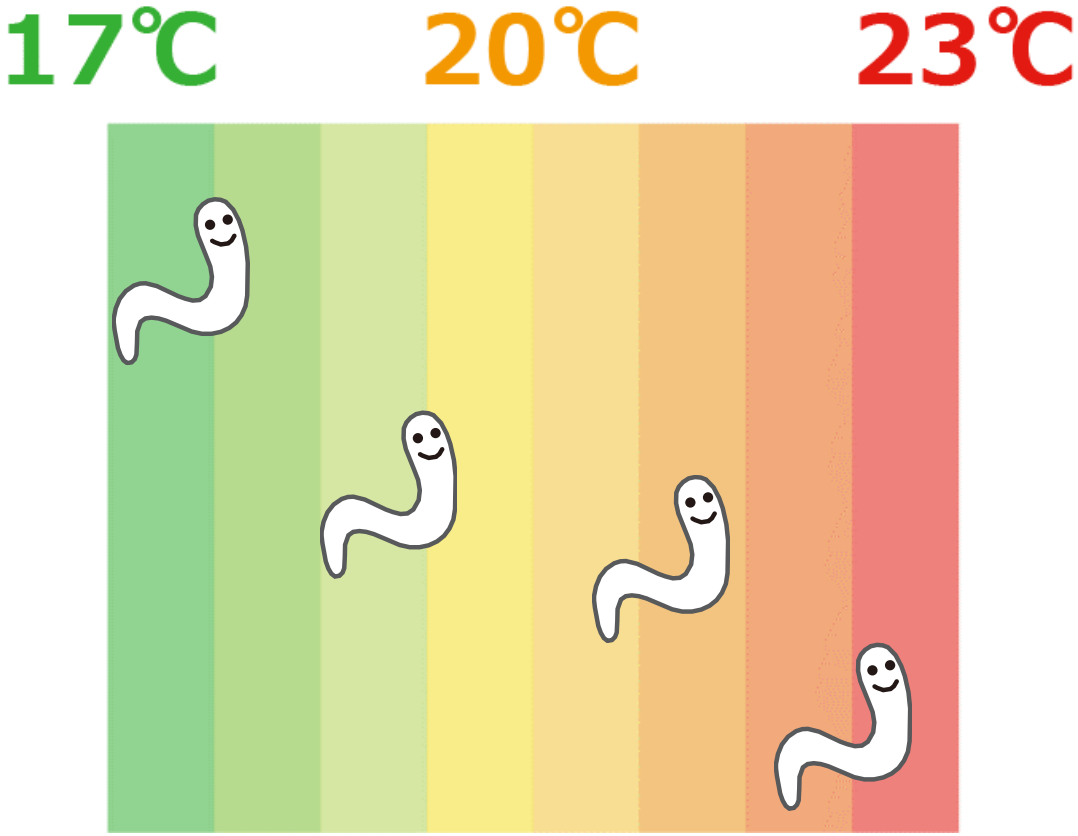
Output

Elegance 3
C. elegans has memory



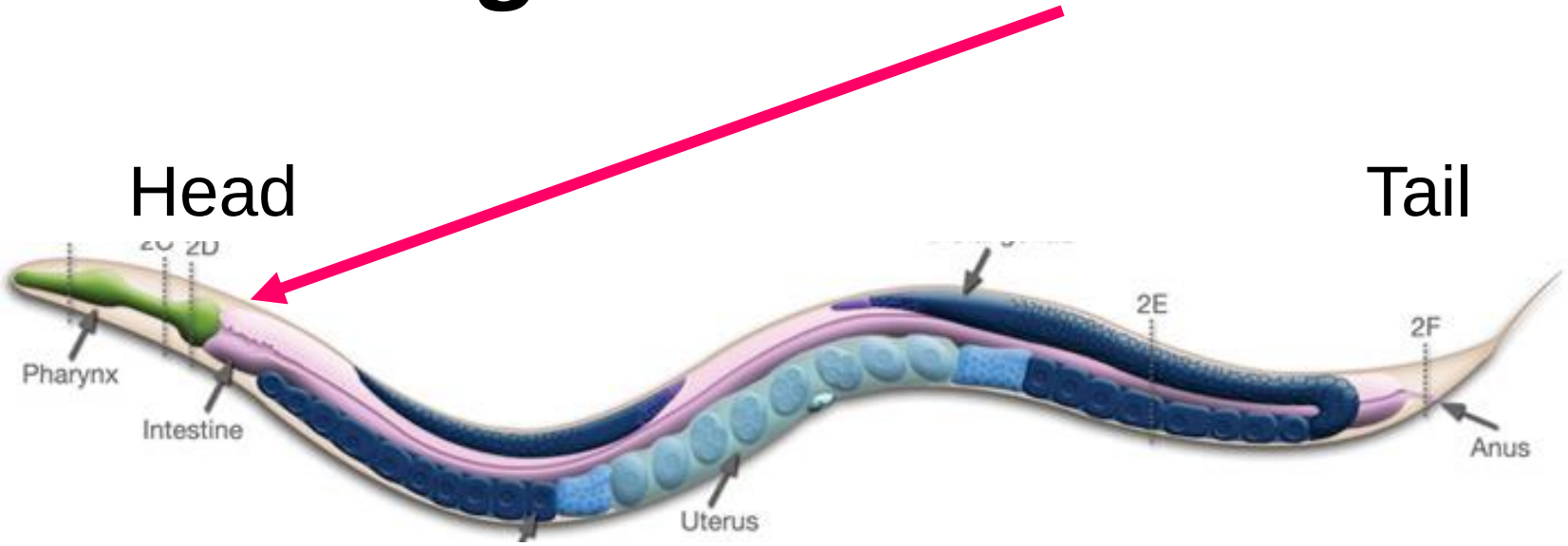
Elegance 3
C. elegans has memory





Hedgecock and Russell, *PNAS,* 1975
Mori and Ohshima, *Nature,* 1995

Elegance 4
C. elegans has a brain



Elegance 5
Every *C. elegans* is the same

302 neurons

 Good for experiments!!

Well, *C. elegans* seems to be good for experiments, but...

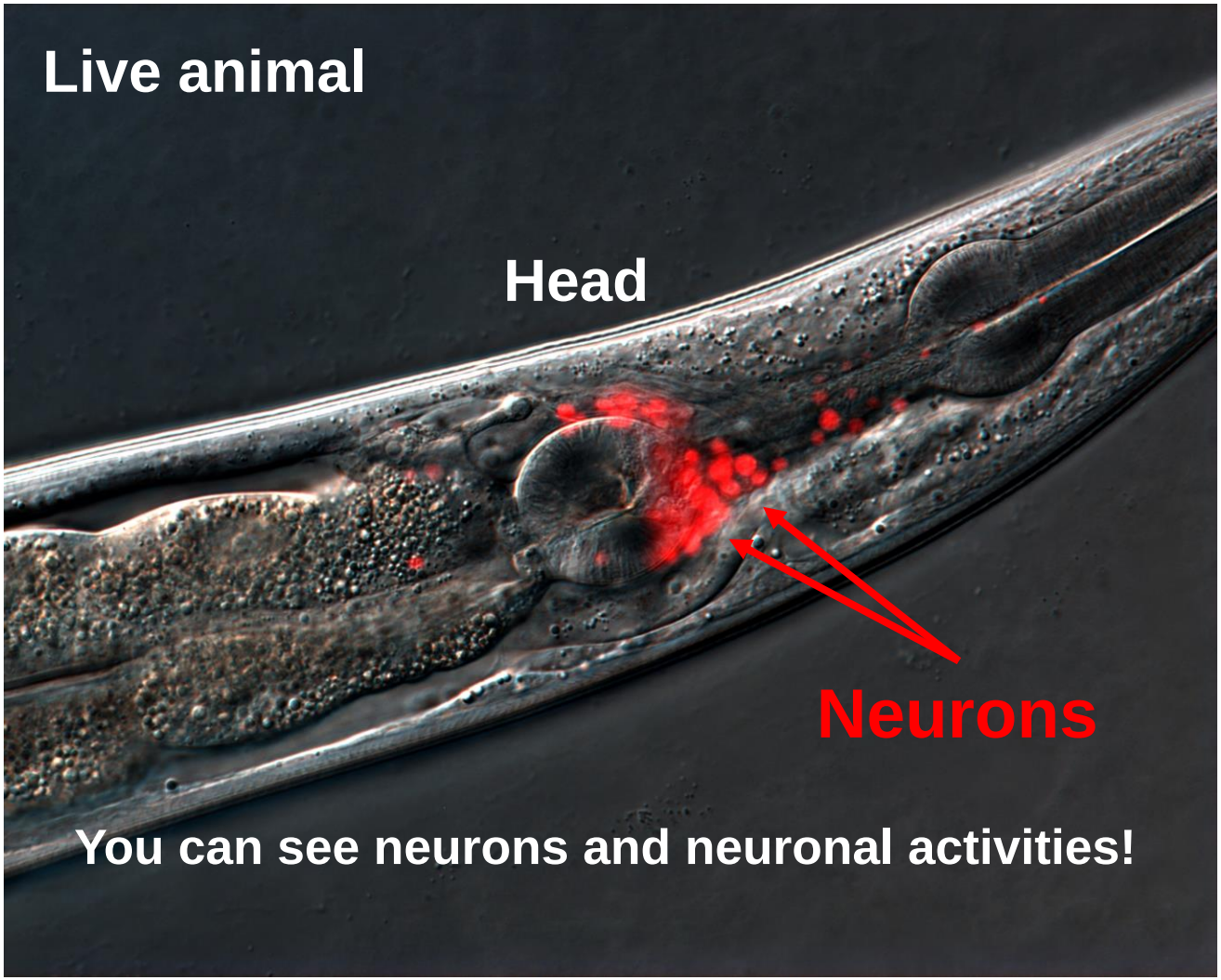
Exciting questions about the brain

How do neurons process information?

How is the brain formed?

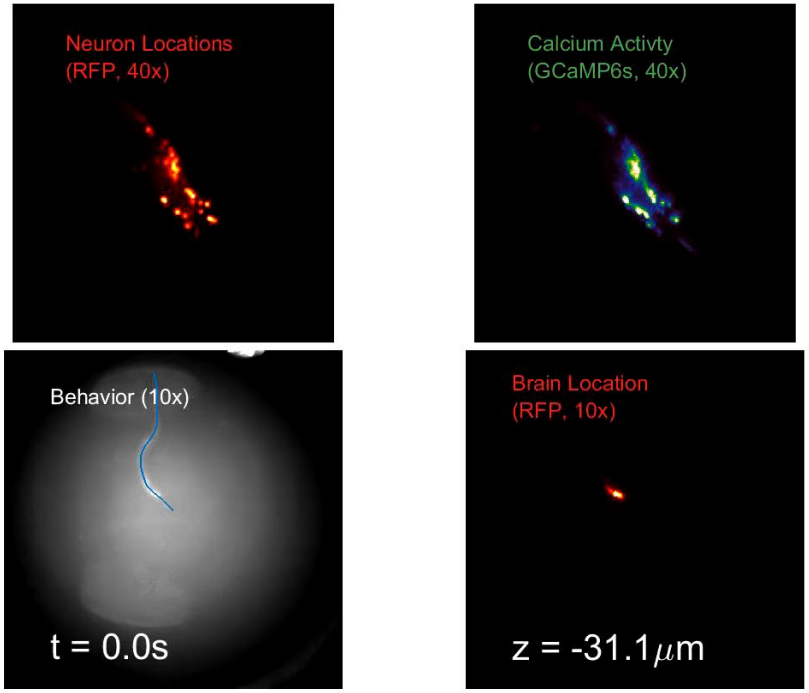
What is the consciousness?

Elegance 6
C. elegans is transparent



Elegance 6

Whole brain activities can be imaged in a freely moving animal



Neuronal activity
=
What *C. elegans*
is “thinking”.

Nguyen et al., *PNAS*, 2016

Neuronal activity → **Core principle of information processing**

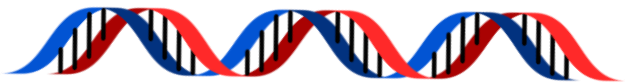
Exciting questions about the brain

How do neurons process information?

How is the brain formed?

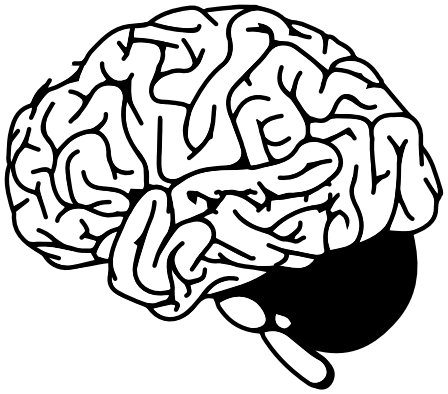
What is the consciousness?

The brain is formed, based on the genome

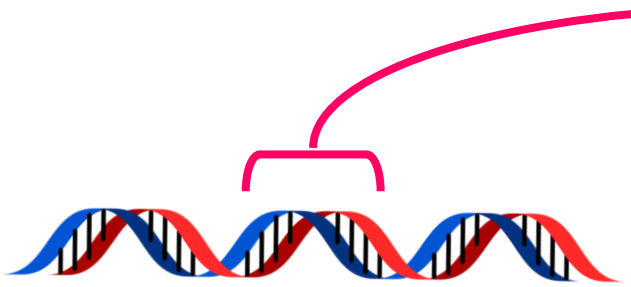


Genome DNA
(Blueprint 設計図)

HOW??



Genes are the functional units of the genome



Genome DNA
(Blueprint 設計図)

Gene
(Functional unit)

20,000 genes in *C. elegans*

Which gene is important for the brain??

Elegance 7
C. elegans is easily manipulated

Elegance 7
C. elegans is easily manipulated

Blueprint
設計図

Gene A

Gene B

Gene C

Forward genetic screen

Important for the brain!

Elegance 7
C. elegans is easily manipulated

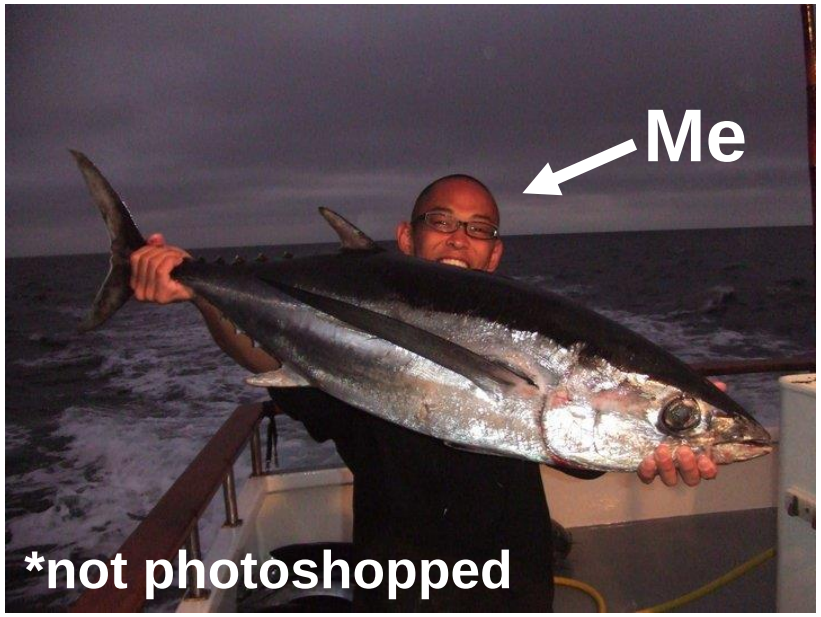
Blueprint
設計図

Gene A

Gene B

Gene C

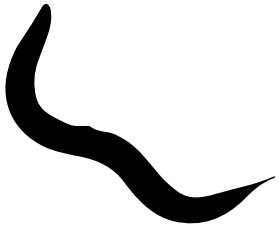
Forward genetic screen



Important for the brain!

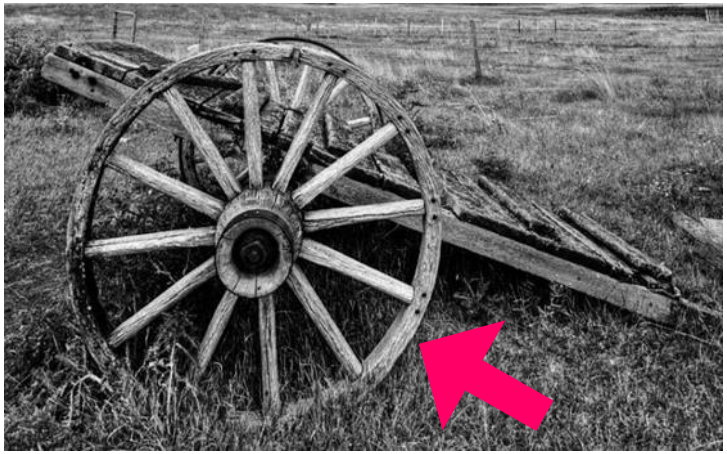
Example: a gene, *unc-13*
important for neuronal communication

Elegance 8
Important genes are conserved
保存されている

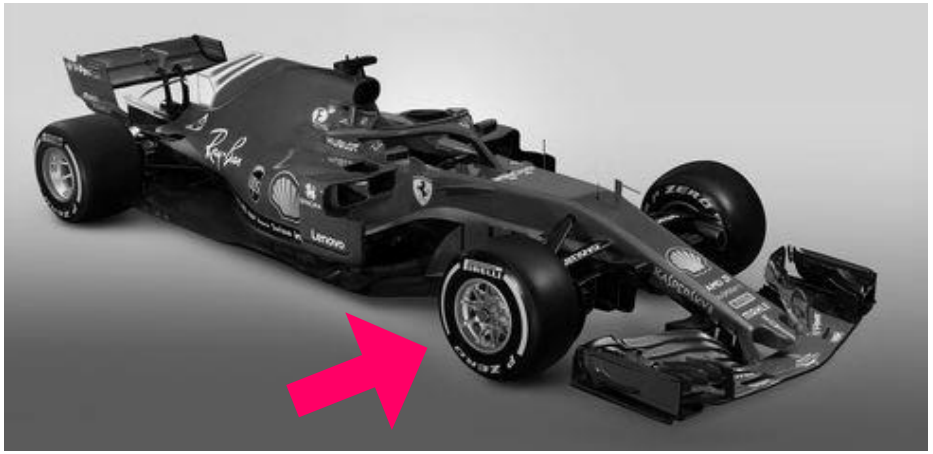


The blueprint

unc-13



https://books.google.co.jp/books/about/Twist_of_Gold.html?id=tJKbQis8-xEC&source=kp_cover&redir_esc=y
2018/10/18



https://response.jp/article/img/2018/02/23/306453/1279152.html?from=arrow-next 2018/10/18

Take-home message

“Model organisms” are powerful!!

Today's menu

- Appetizer -

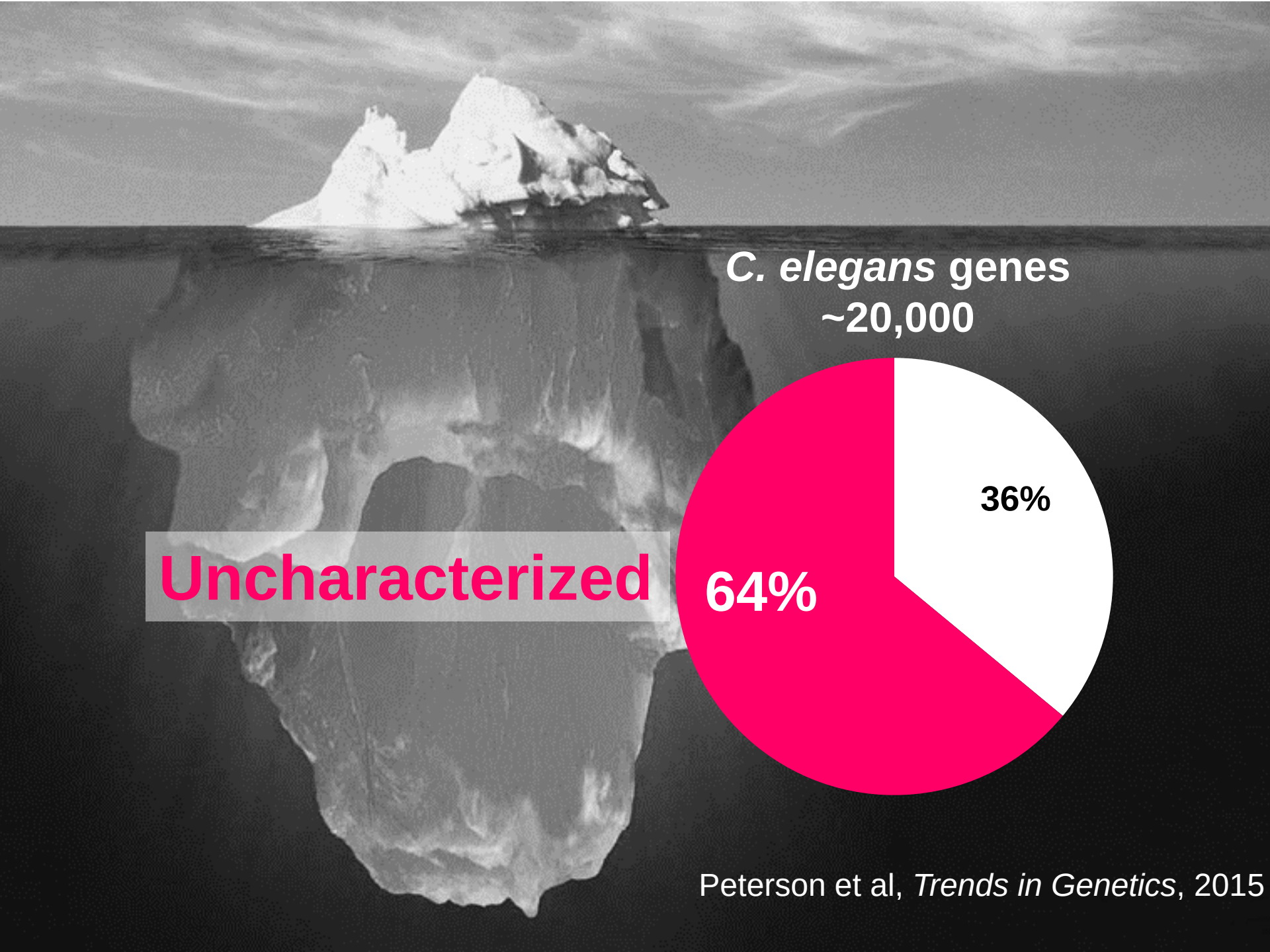
Brain

- Main dish -

Worm

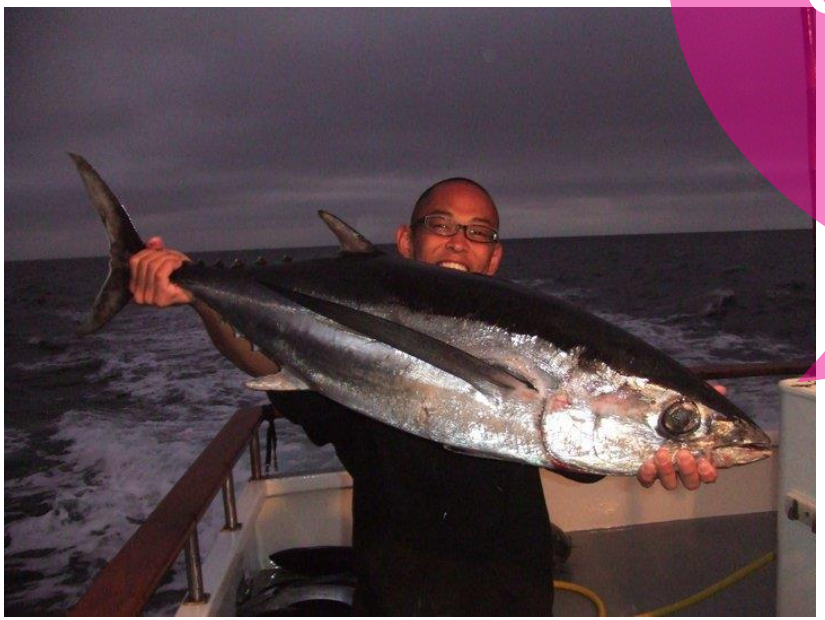
- Dessert -

Me



Peterson et al, *Trends in Genetics*, 2015

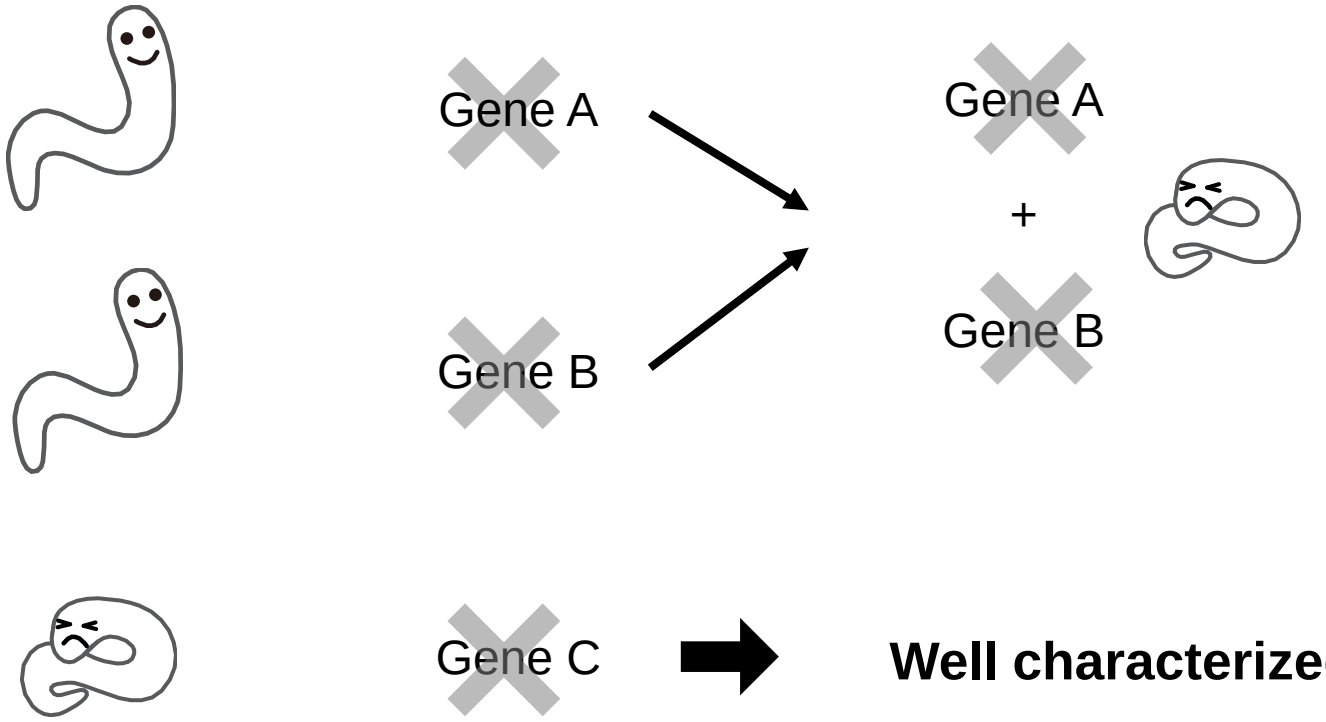
I want to find and characterize new genes!!



Forward genetic screen

0 + 0 = 1

Blueprint
設計図



Combination is challenging

Combination of two genes

$_{20,000}C_2 = 199,990,000$

NEW
Forward genetic screen

I can do it with *C. elegans*!

1. Maintenance
2. Sensation
3. Memory
4. Brain
5. Stereotype
6. Transparency
7. Manipulation
8. Conservation


I hope
you see elegance
in the C. elegans brain

Thanks!

Contact
Kentaro (Ken) Noma
Science building B103
075-789-2501
noma.kentaro@e.mbox.nagoya-u.ac.jp

2012.10.31 @San Diego, USA