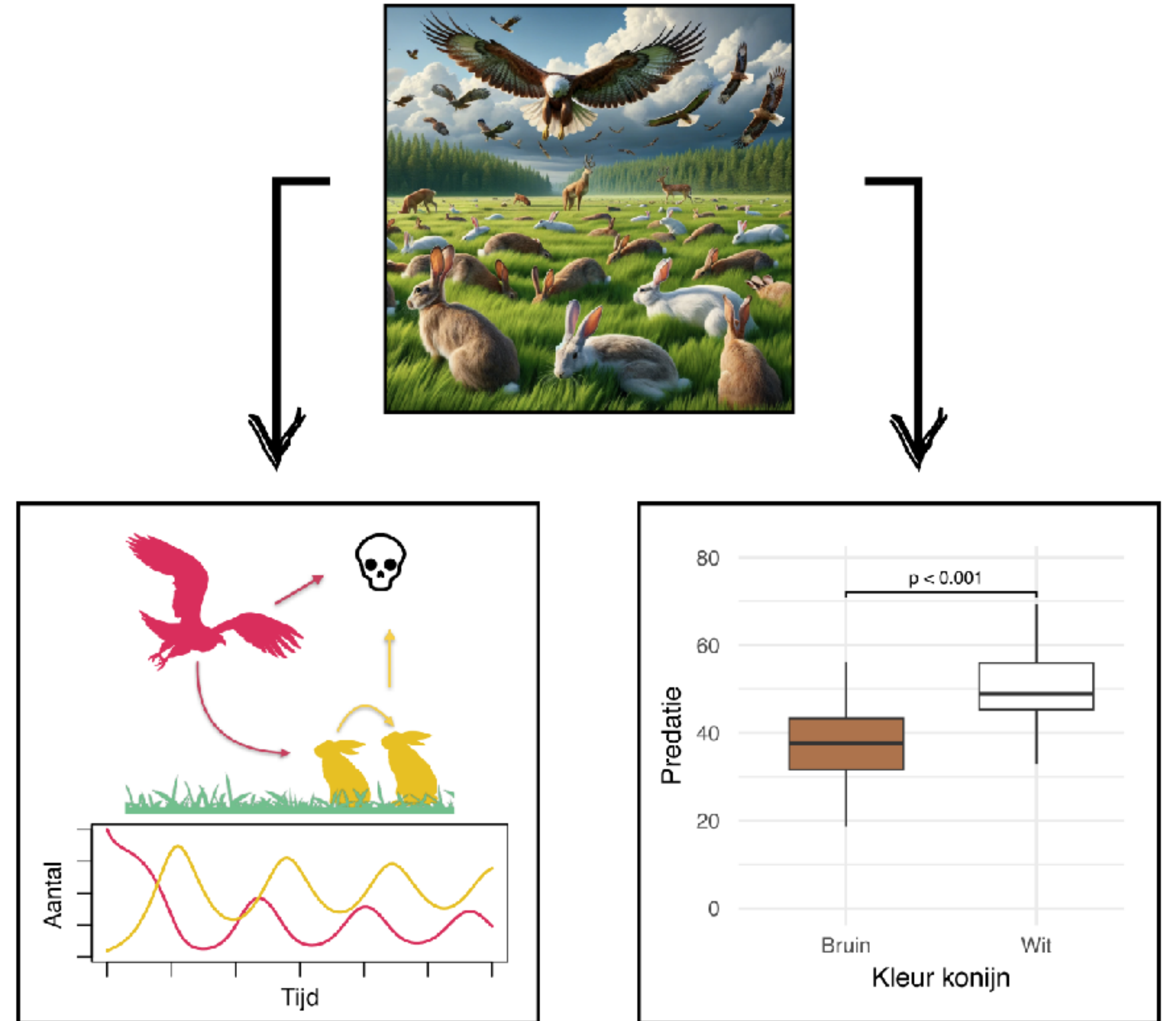


Introductiecollege Biologische Modellen en Statistiek / Kwantitatieve Biologie

Bram van Dijk (hij/hem)



Test je intuïtie als bioloog

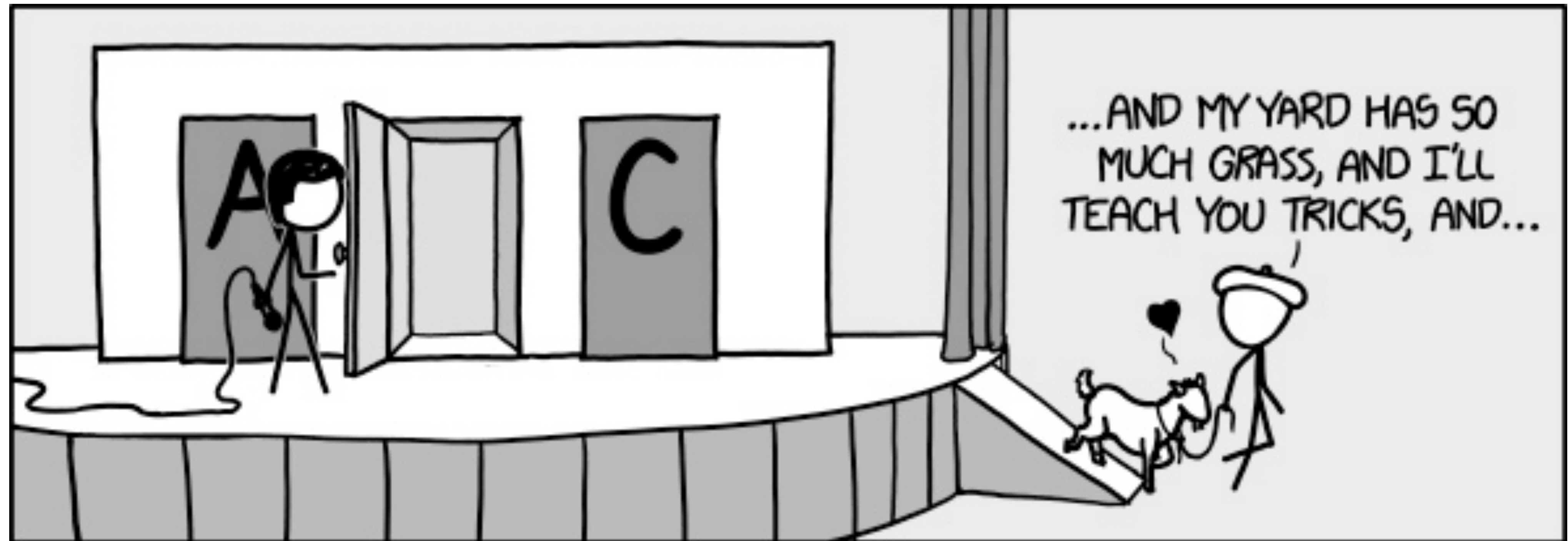
<https://app.wooclap.com>

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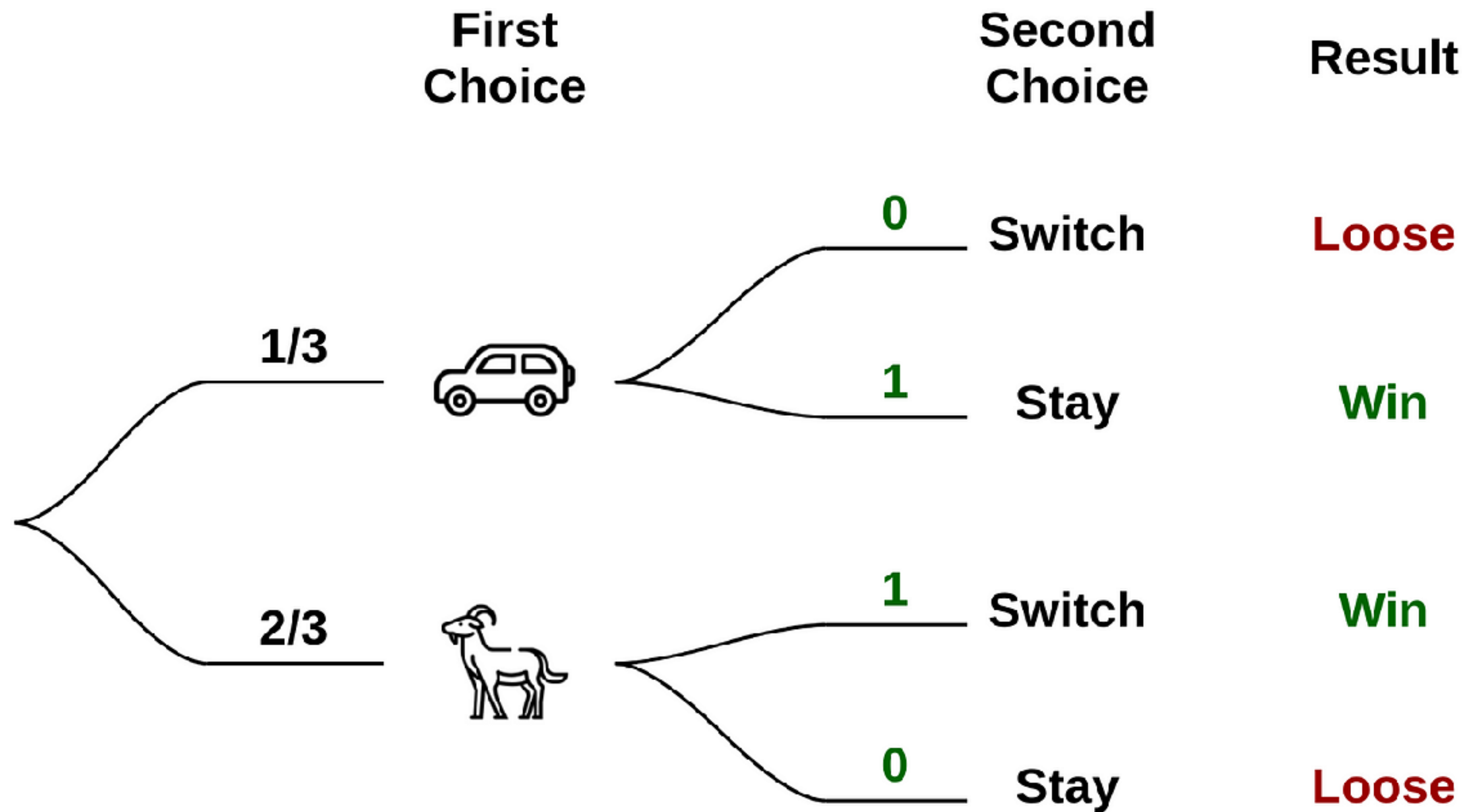
wooclap



Hoe zit dat met die geit dan?



“Monty hall” problem



Hoe zit dat met die geit dan?

Play the Monty Hall game or run the simulation many times to better understand one of the most famous [math riddles](#).



<https://www.mathwarehouse.com/monty-hall-simulation-online/>

Ook in biologie: onze intuïtie is niet genoeg

Ook in biologie: onze intuïtie is niet genoeg



Knijntjes op de Veluwe

Ook in biologie: onze intuïtie is niet genoeg



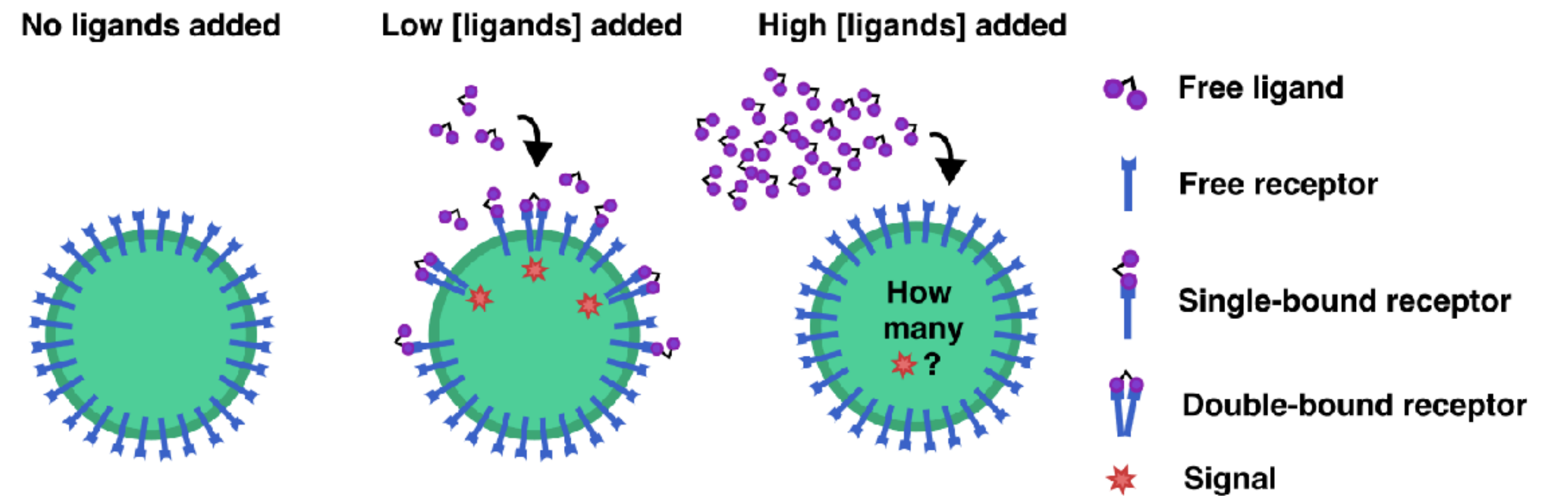
Knijptjes op de Veluwe

Ook in biologie: onze intuïtie is niet genoeg



Knijptjes op de Veluwe

ChatGPT4

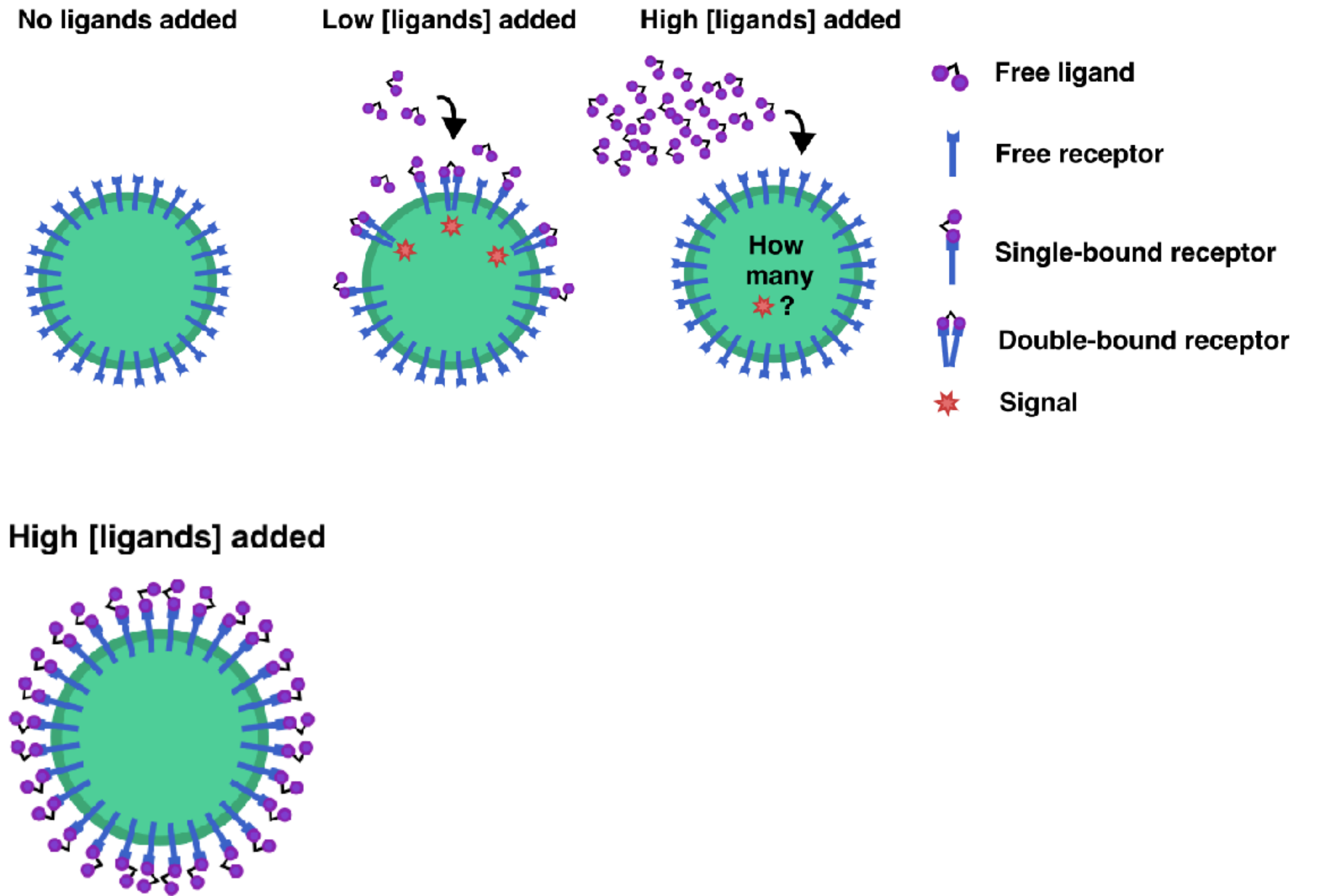


Ook in biologie: onze intuïtie is niet genoeg



Knijptjes op de Veluwe

ChatGPT4

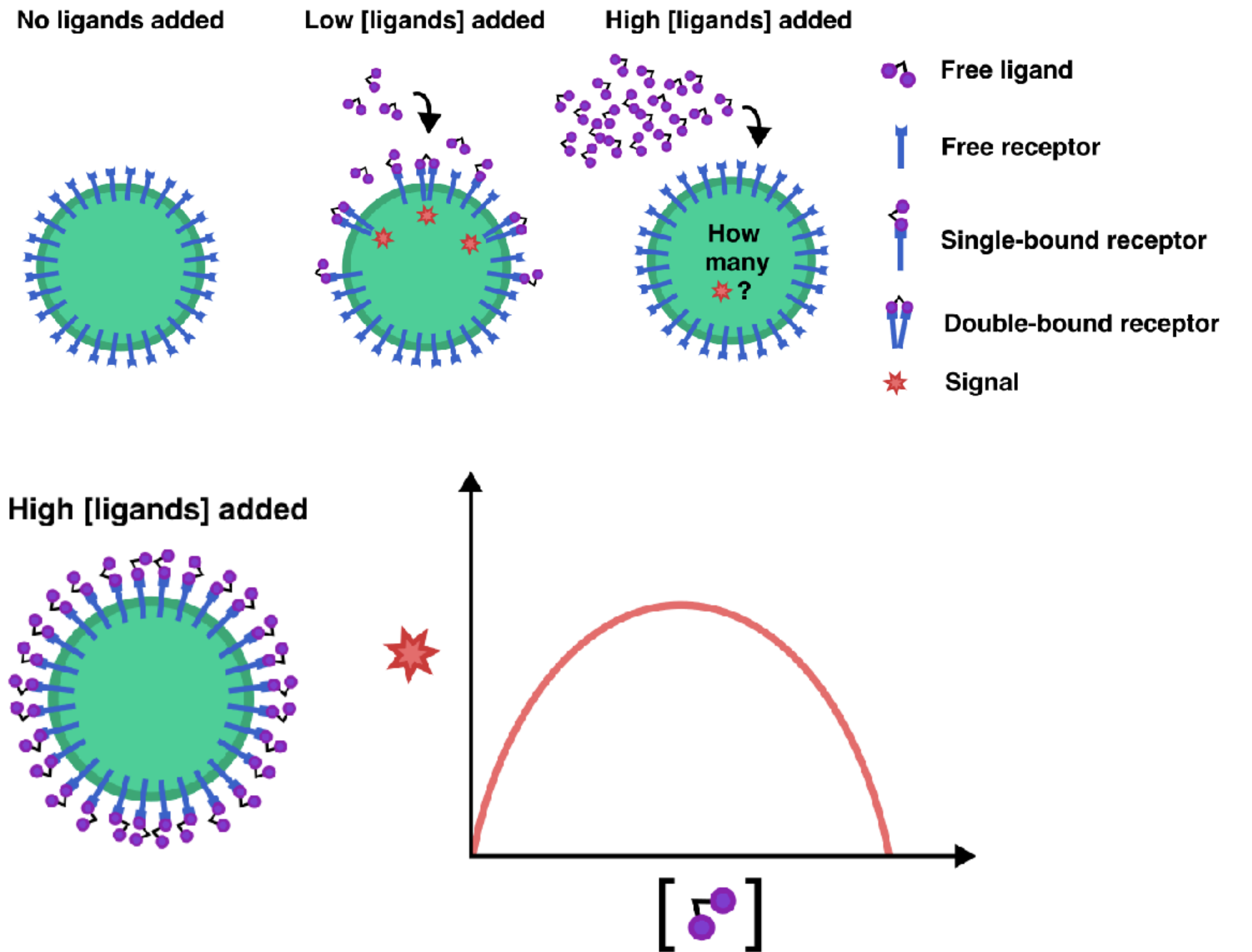


Ook in biologie: onze intuïtie is niet genoeg



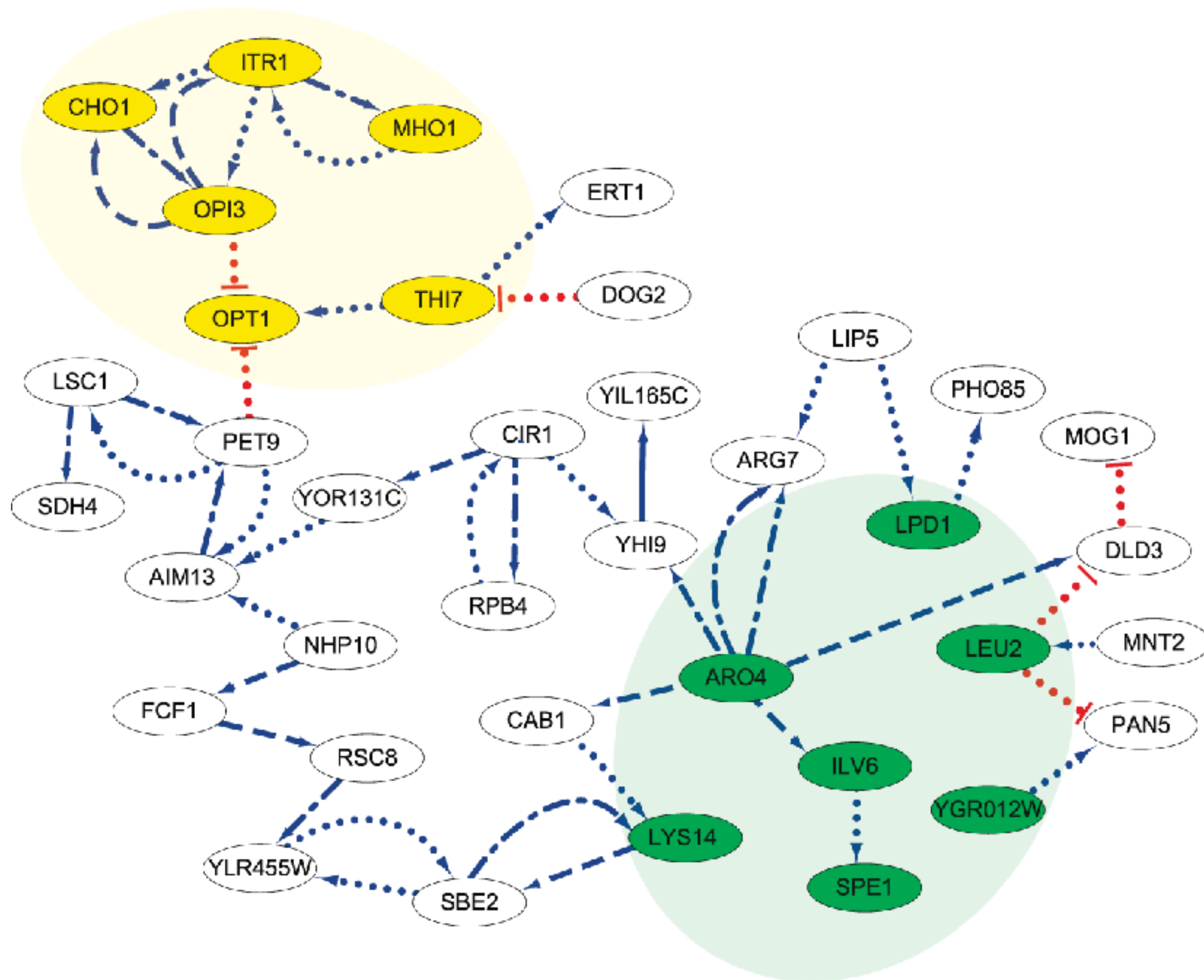
Knijptjes op de Veluwe

ChatGPT4

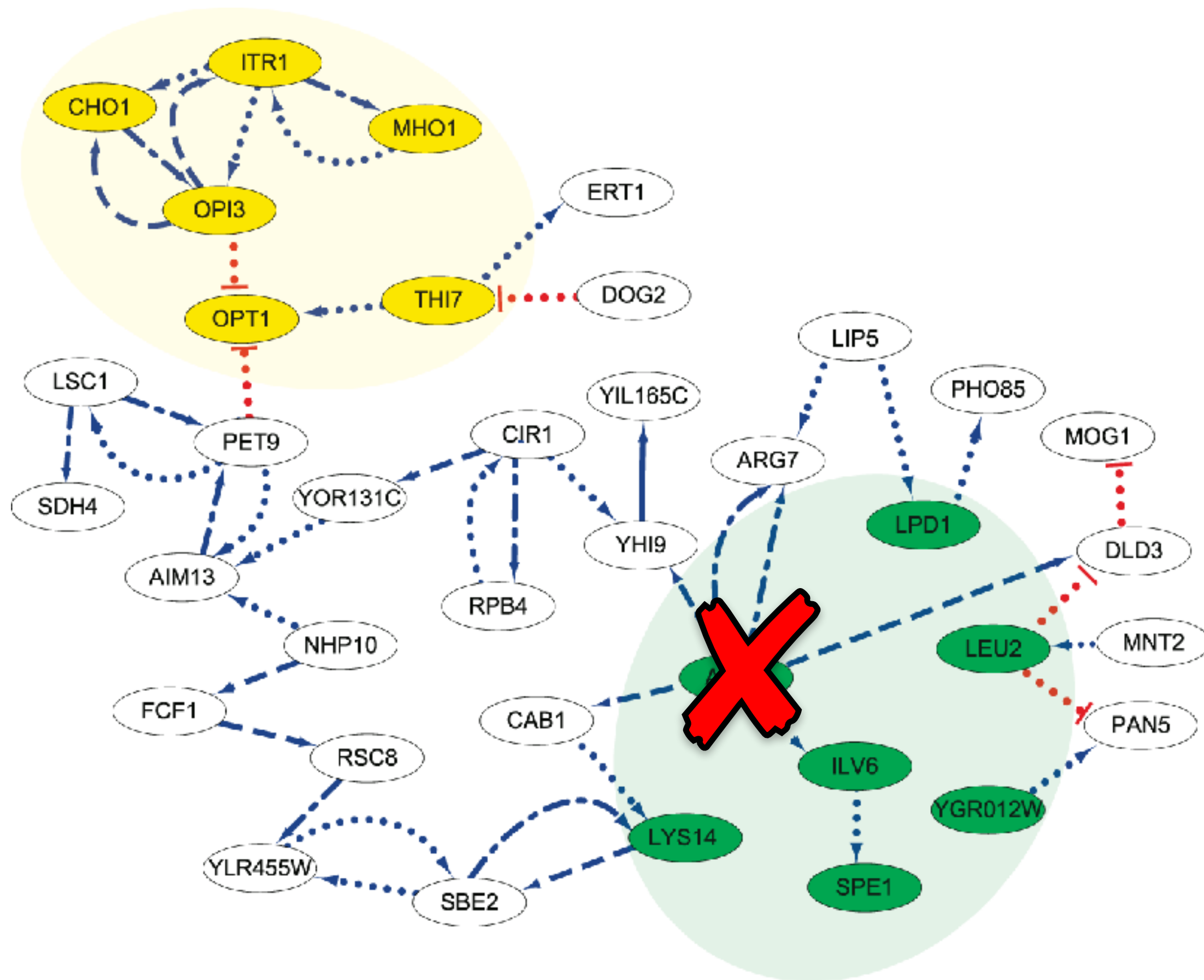


Wat moeten we dan met al die ingewikkelde vraagstukken?

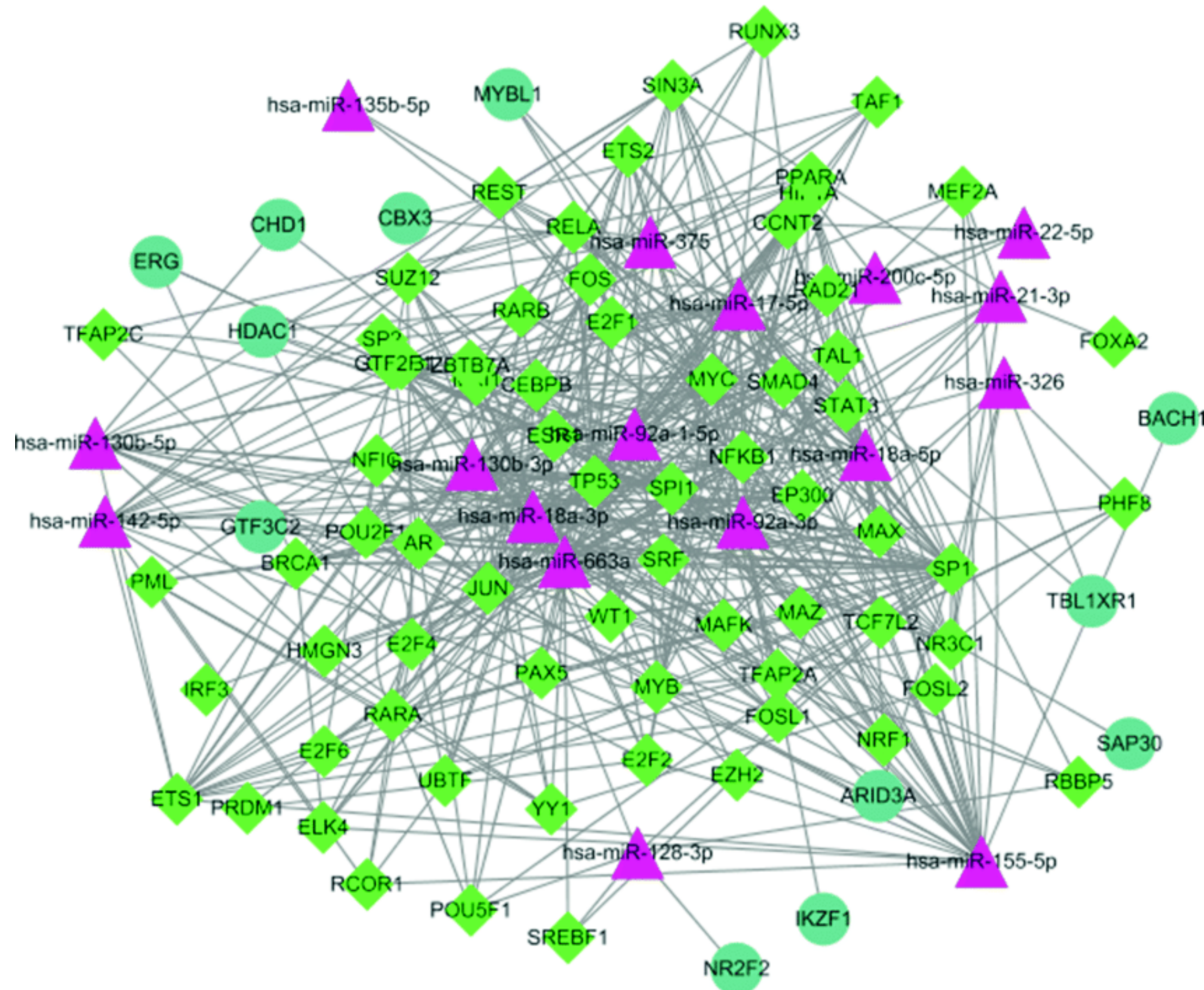
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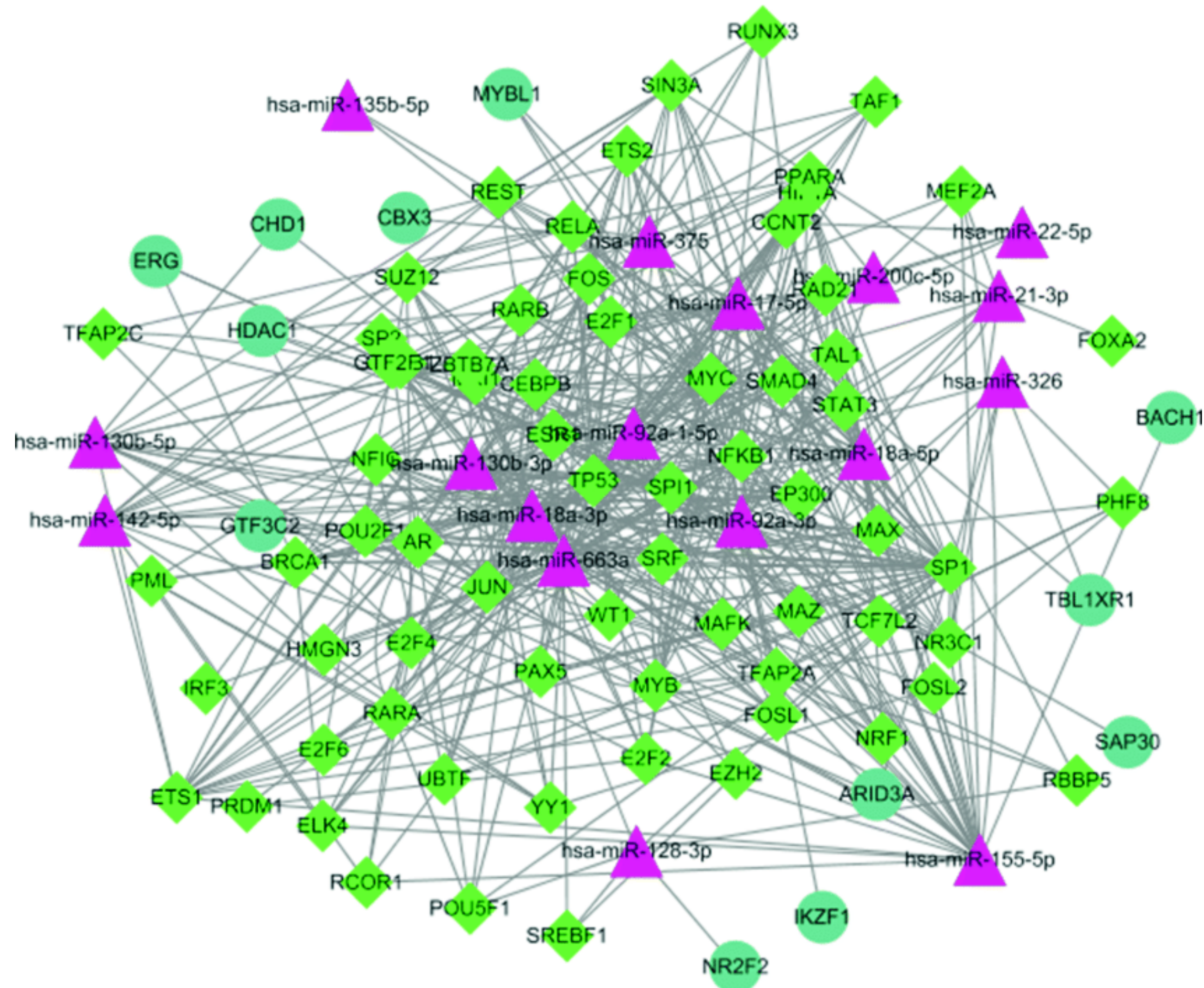
Wat moeten we dan met al die ingewikkelde vraagstukken?



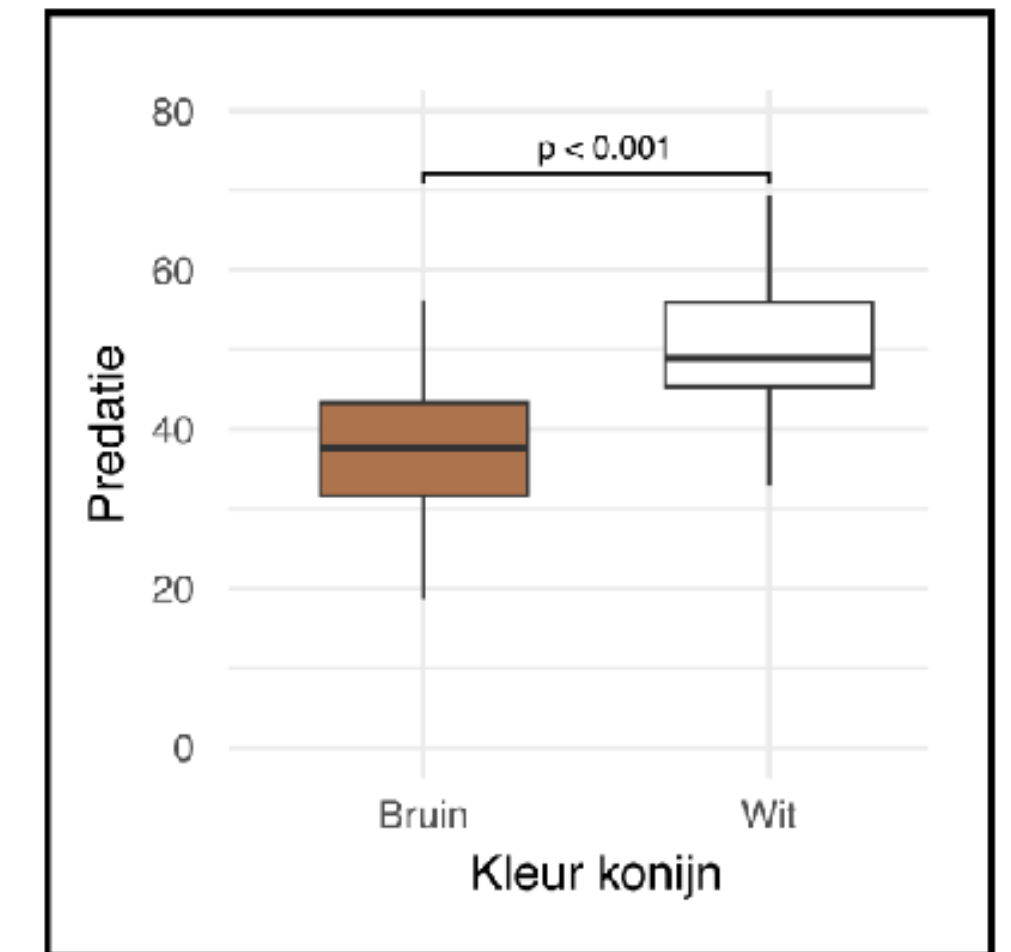
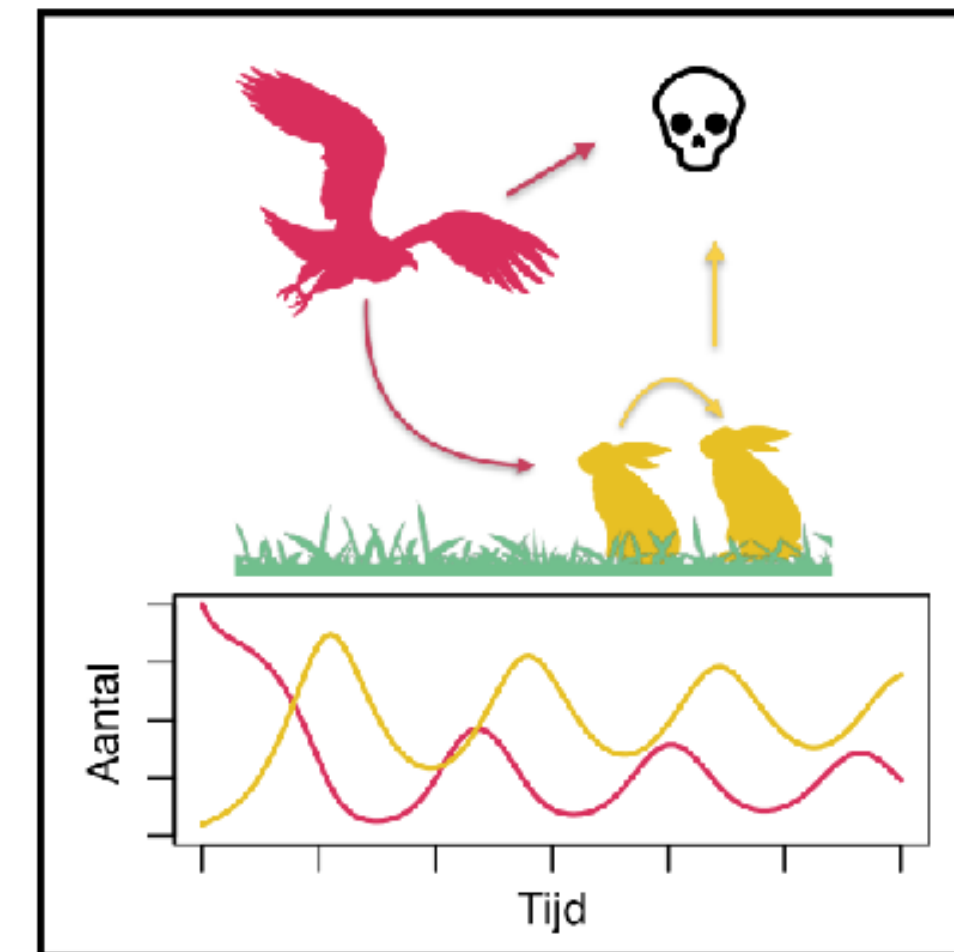
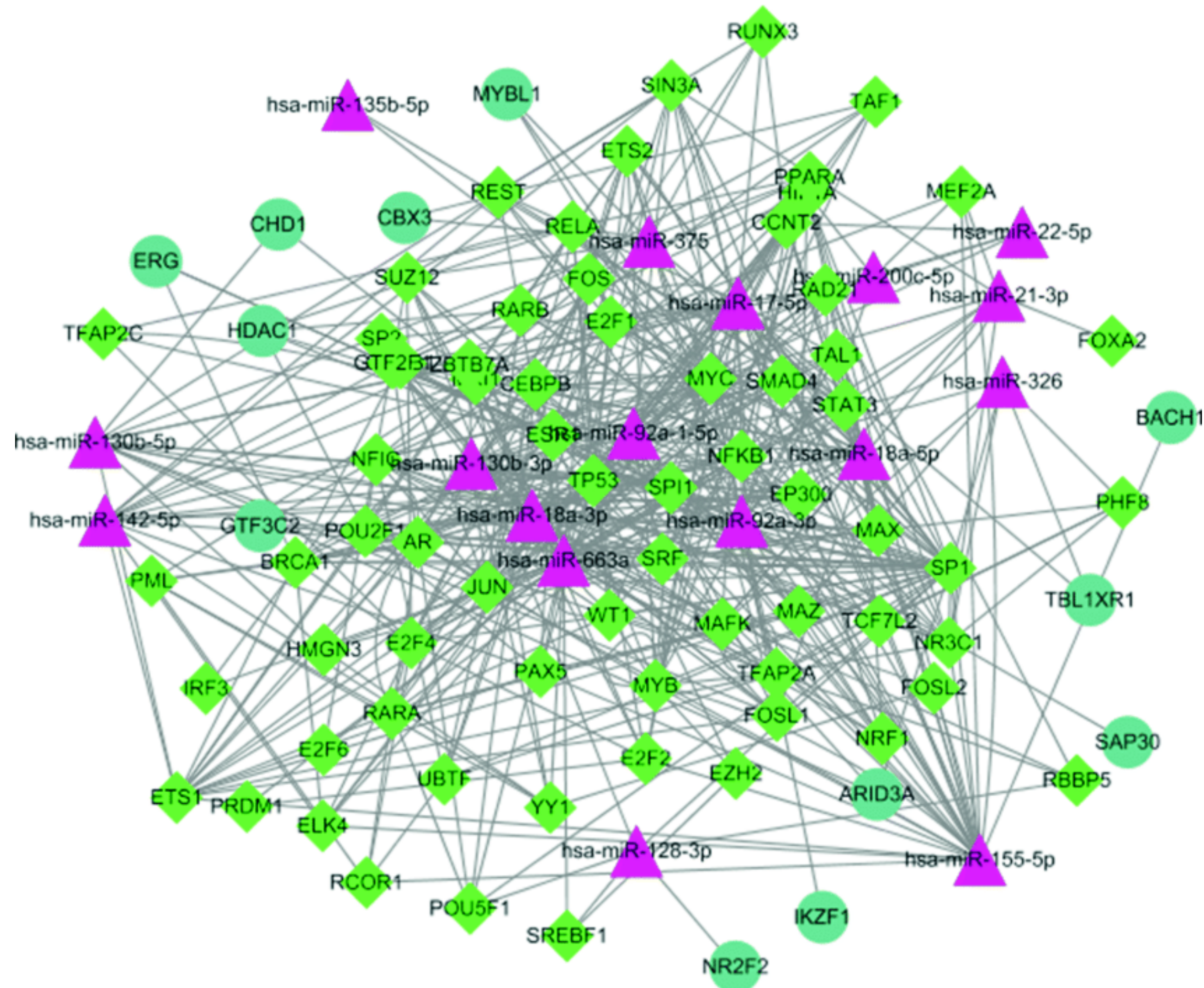
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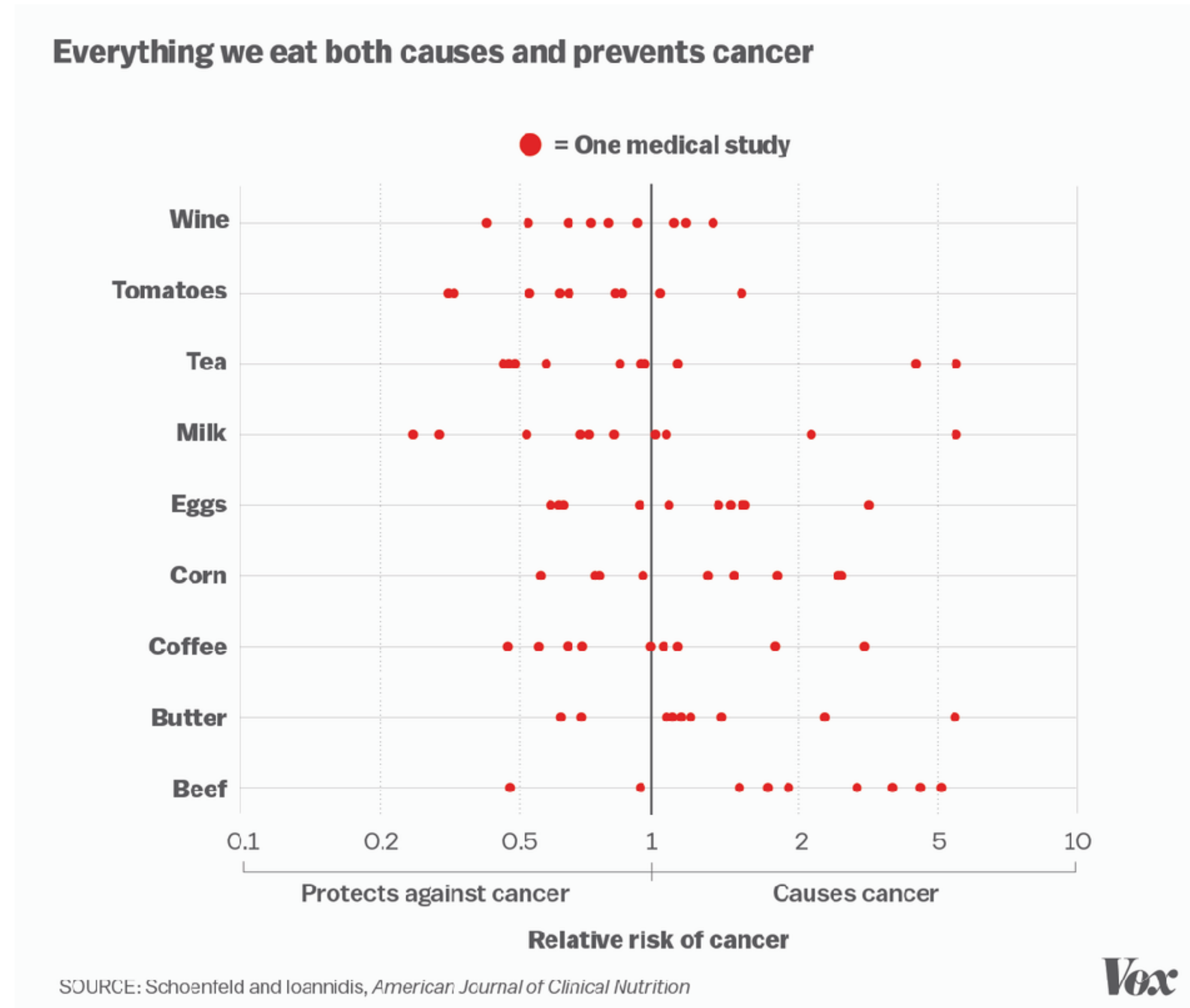
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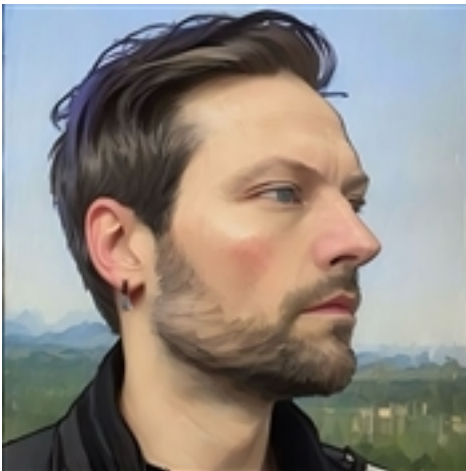
Biologische modellen en statistiek

Een goede bioloog kan **betrouwbare conclusies** trekken...

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Docenten



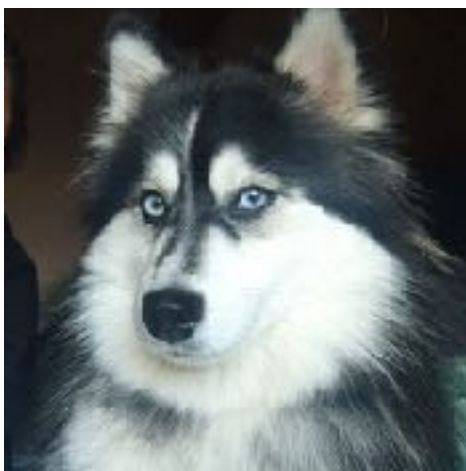
Bram van Dijk

Onderzoeksgroep Theoretische Biologie
H.R. Kruytgebouw, Padualaan 8, kamer N605



Rutger Hermsen

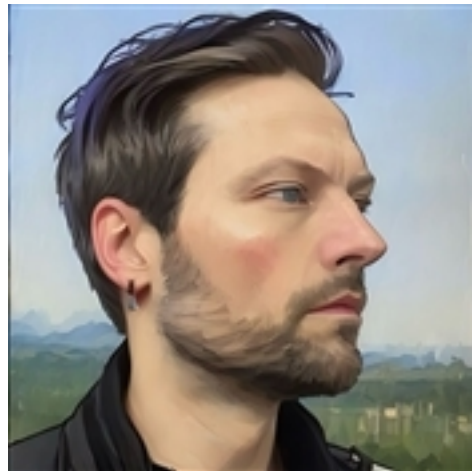
Onderzoeksgroep Theoretische Biologie
H.R. Kruytgebouw, Padualaan 8, kamer N602



Christa Eekhuis

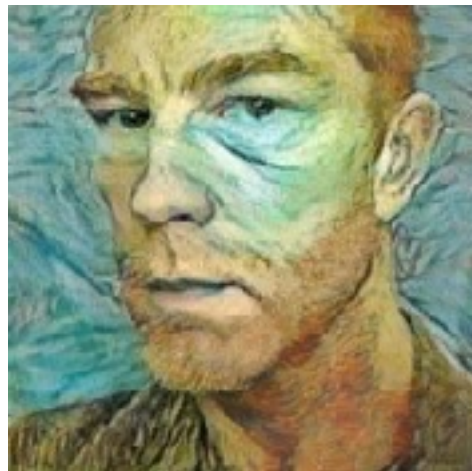
Eerstejaarscoördinator / promovendus
H.R. Kruytgebouw, Padualaan 8, kamer N404

Docenten



Bram van Dijk

Onderzoeksgroep Theoretische Biologie
H.R. Kruytgebouw, Padualaan 8, kamer N605



Rutger Hermsen

Onderzoeksgroep Theoretische Biologie
H.R. Kruytgebouw, Padualaan 8, kamer N602



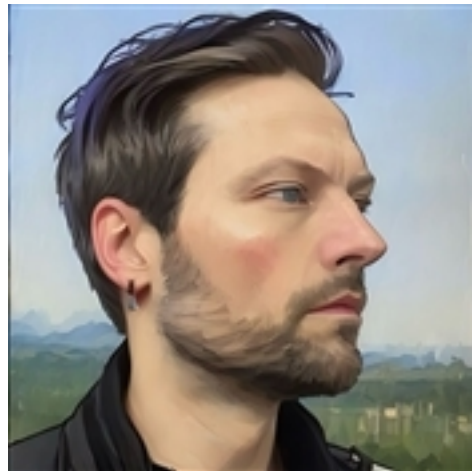
Christa Eekhuis

Eerstejaarscoördinator / promovendus
H.R. Kruytgebouw, Padualaan 8, kamer N404

Inhoudelijke vragen?

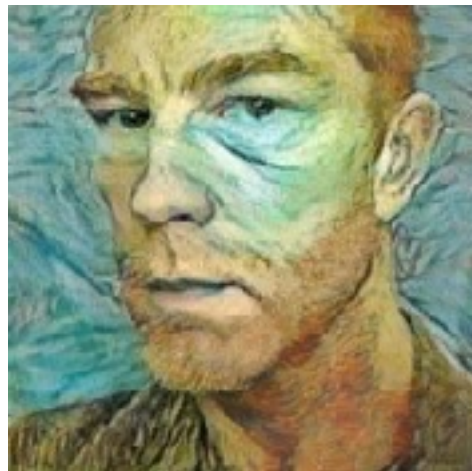
Teams: `wv540vy`

Docenten



Bram van Dijk

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H.R. Kruytgebouw, Padualaan 8, kamer N605



Rutger Hermsen

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H.R. Kruytgebouw, Padualaan 8, kamer N602



Christa Eekhuis

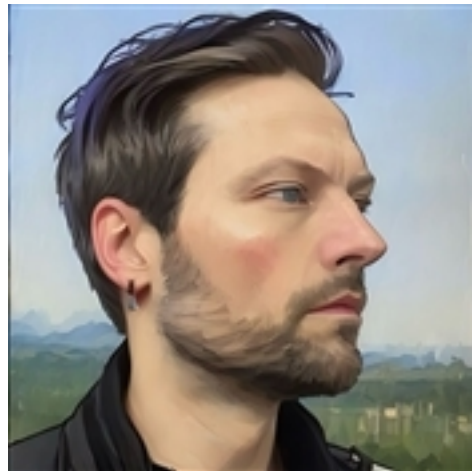
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Inhoudelijke vragen?

Teams: `wv540vy`

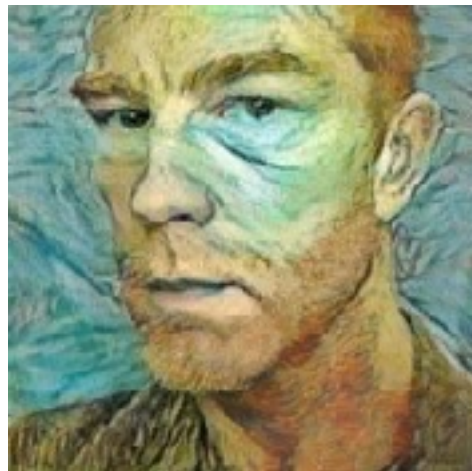
Algemene vragen?

Docenten



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H.R. Kruytgebouw, Padualaan 8, kamer N404

Inhoudelijke vragen?

Teams: [wv540vy](#)

Algemene vragen?

kwantitatieve.biologie@uu.nl

De cursuswebsite / “het cursusboek”



bioms-uu.github.io



The screenshot shows the course website interface. On the left is a navigation menu with the BMS logo and a search bar. The main content area displays the course title, author information, and the start of the introduction text.

BMS
Biologische Modellen en Statistiek

Cursusinformatie > Inleiding

Biologische Modellen en Statistiek

AUTEUR: Vakgroep Theoretische Biologie, Universiteit Utrecht
PUBLICATIEDATUM: 20 juni 2024

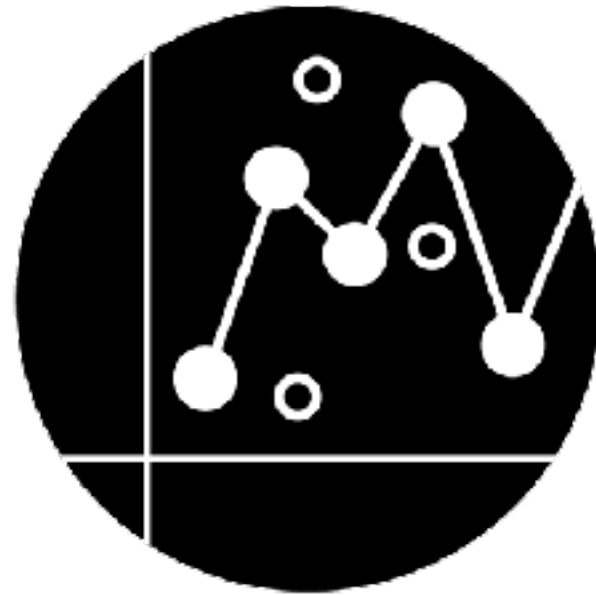
Inleiding

Biologie is een complexe wetenschap. Biologische systemen bestaan uit vele componenten die hun eigen schaal unieke regels en processen volgen. We bestuderen nucleotiden, eiwitten, cellen, weefsels, organen, organismen, en ecosystemen, waarbij de schaal over meerdere ordegrottes varieert. Bovendien hebben deze schalen allemaal invloed op elkaar: een klein detail vormt het toneel waarop dieren, planten, microben en hun mutaties zich verspreiden, en deze spelers beïnvloeden op hun beurt ook het ecosysteem! Misschien is het dus ook geen verrassing dat zoveel variatie zit in biologische metingen, want de allerkleinste details doen ertoe. We proberen om deze complexe systemen, met al deze ingewikkelde details, toch te begrijpen.

Vaardigheden die je gaat opdoen tijdens deze cursus



Kritisch denken



Omgaan met data



Samenwerken



Schrijven

Onderdelen van de cursus

Onderdelen van de cursus

1. Basis van 'R' en wiskunde



$$g^{\log(a)} = b \quad \text{tot de macht}$$

$$g^b = a \quad \text{is}$$

Rekenregel

$$a^n \cdot a^m = a^{n+m}$$

$$a^n \div a^m = a^{n-m} \text{ als } a \neq 0$$

$$(a^n)^m = a^{nm}$$

$$(a^n \cdot b^m)^q = a^{nq} \cdot b^{mq}$$

Rekenregel

$$b \log b^a = a$$

$$\log a + \log b = \log ab$$

$$\log a - \log b = \log a/b$$

Onderdelen van de cursus

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$$g^b = a \quad \text{is} \quad \log$$

Rekenregel

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Rekenregel

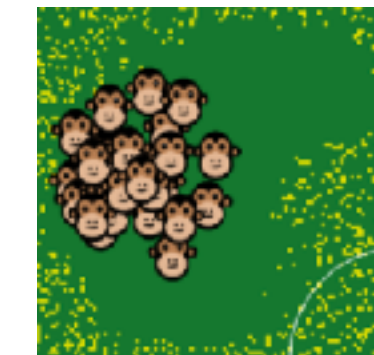
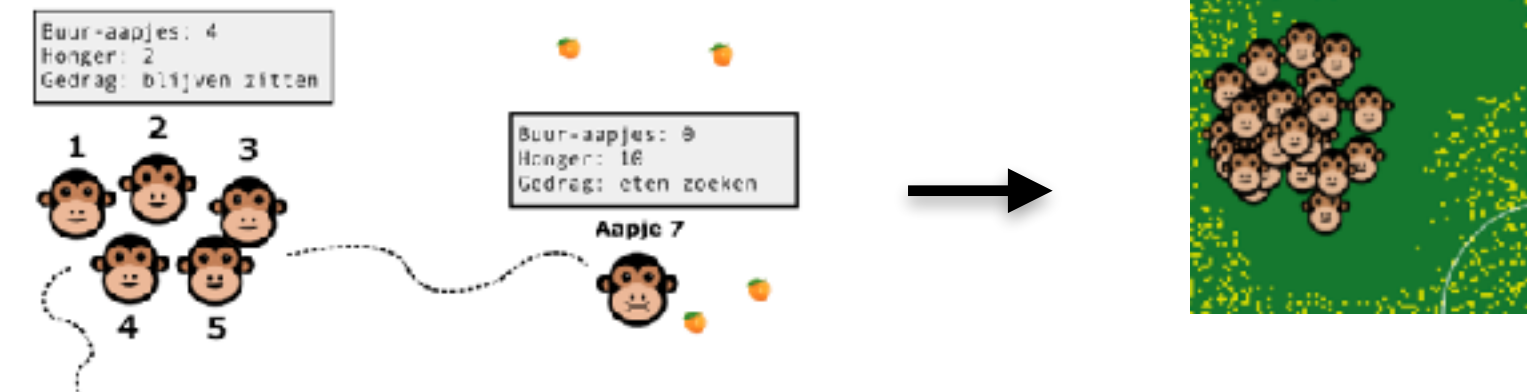
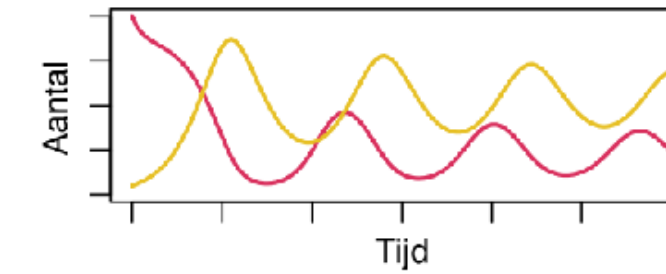
$$b^{\log b^a} = a$$

$$\log a + \log b = \log ab$$

$$\log a - \log b = \log a/b$$

2. Biologische modellen

$$\frac{dN}{dt} = b \left(1 - \frac{N}{K} \right) N - dN \rightarrow$$



Onderdelen van de cursus

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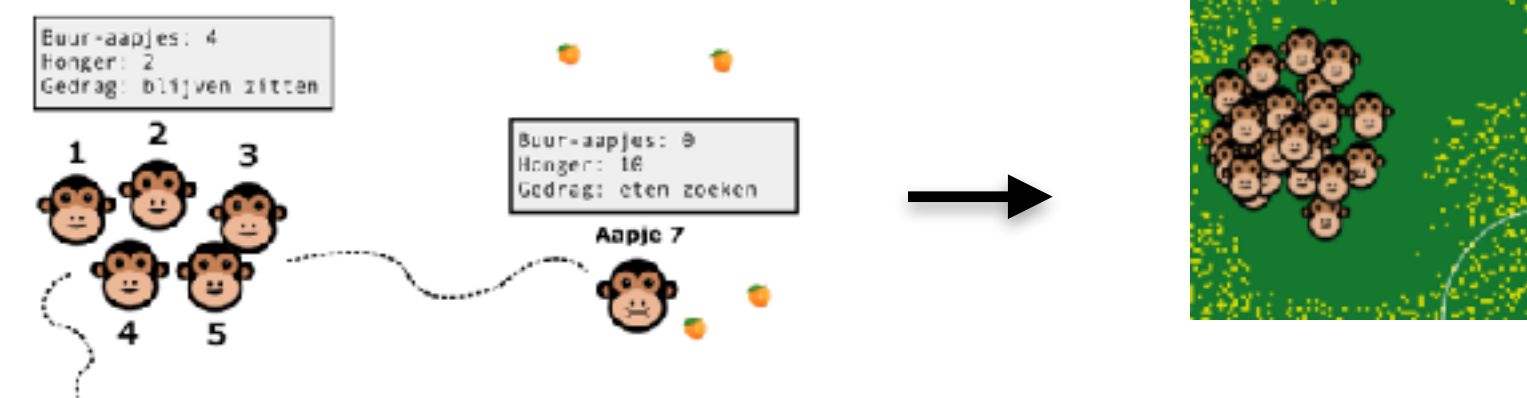
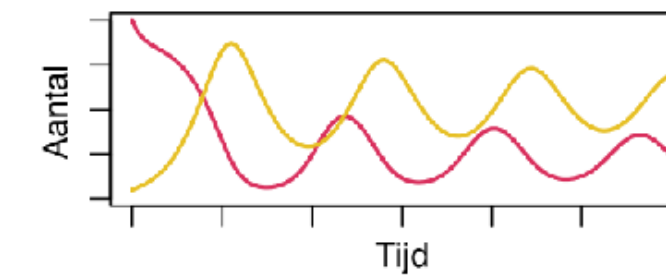
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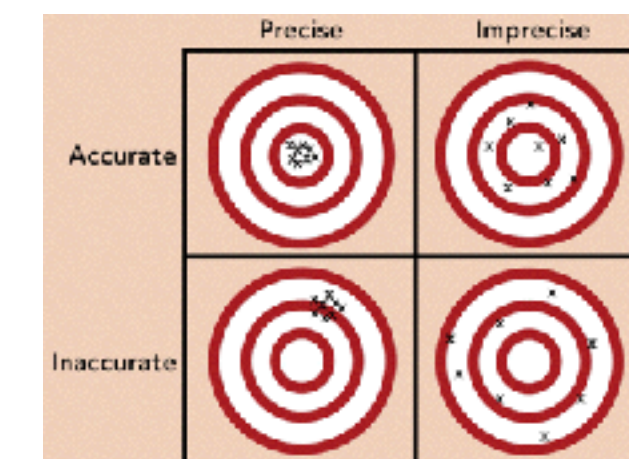
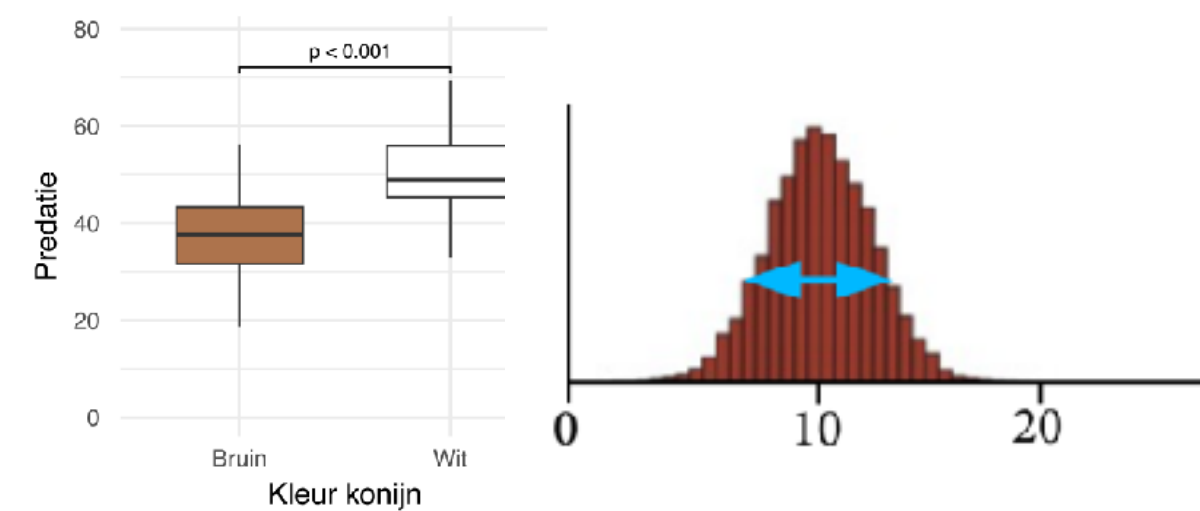
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3. Statistiek



Programmeren en modelleren zijn **biologische**
basisvaardigheden geworden

Programmeren en modelleren zijn biologische basisvaardigheden geworden

PhD Effects of pesticide mixtures on insects

Published	Deadline	Location
21 Jan	16 Feb	Wageningen



JOB DESCRIPTION

Do you want to study the effects of pesticides on insect diversity in different types of farms? And the effects of pesticide mixtures on honeybees and bumblebees in small-scale experiments? Do you have proven affinity with quantitative analysis and laboratory experience? Then this could be the perfect PhD project for you!

REQUIREMENTS

- a MSc in biology (ecology), microbiology, host-microbe interactions, animal sciences, ecotoxicology, veterinary medicine
- proven affinity with quantitative analysis (statistical analyses, microbiome analysis and/or mathematical modelling)
- experience with working in a laboratory
- excellent communication and writing skills
- a creative and collaborative personality
- have excellent command of English (preferably contributed to a peer-reviewed

Programmeren en modelleren zijn biologische basisvaardigheden geworden

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- proven affinity with quantitative analysis and/or mathematical modelling)
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- a creative and collaborative personality
- have excellent command of English (native or near-native)

Postdoc position: "Understanding large scale spatiotemporal distributions of macrozoobenthos in the Dutch Wadden Sea"

Published	Deadline	Location
23 Dec	14 Feb	't Horntje (Texel)



JOB DESCRIPTION

The department of Coastal Systems (COS) is looking for a highly motivated Postdoc. We offer a postdoctoral position of 3 years on studying the spatiotemporal variation in macrozoobenthos in the group of Dr. Allert Bijleveld. This project is part of ongoing research on understanding trends and spatial distributions of benthic communities in the Dutch Wadden Sea.

REQUIREMENTS

Applicants must have a PhD degree, or aim to submit their PhD thesis for assessment by spring 2021. A background in ecology, macrozoobenthos, experience with handling large data sets, and the analysis of spatiotemporal distributions are required. Because the successful candidate will have large amounts of spatiotemporal data available, strong statistical, analytical, and computational skills are critical. The successful candidate is also expected to have good collaborative skills and proven abilities to

Programmeren en modelleren zijn biologische basisvaardigheden geworden

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PhD position - Food and land use system transformations in Europe;

Your qualities

We are seeking an enthusiastic and results-driven candidate who meets the following criteria:

- A successfully completed MSc degree in:
 - Agricultural or business economics, with an interest in food and land use systems; or
 - Food system governance, with proven interest in economics and sustainability;
- Strong teamwork skills for transdisciplinary co-creation and collaboration;
- Proficiency in both oral and written English (C1 level or equivalent) ;
- Analytical skills with experience and interest in modelling;
- Regional knowledge (preferred): Affinity with European food and land use systems.

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- Proficiency in both oral and written English
- **Analytical skills with experience and interest in data analysis**
- Regional knowledge (preferred): Affinity with food systems.



PhD-position: Deep-sea predator-prey interactions

- A Master's degree in marine ecology/biology, oceanography or a closely related discipline
- Experience with cetacean and/or deep-sea cephalopod or fish ecology in the field and/or in the lab, in multi-disciplinary research settings
- Ability to grasp ecological concepts and perform integrative analysis from multiple data streams
- A demonstrated ability to work on programming software such as R, Python or Matlab
- Strong communication and writing skills in English
- You are a team player and well organized, but also able to work independently
- Affinity with field work and working/living in a team
- Driving license B
- Previous experience with one of more of the following techniques is an advantage: biologging, echo sounders, species-habitat association modelling (or comparable)

Programmeren en modelleren zijn biologische basisvaardigheden geworden

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JOB DESCRIPTION

Do you want to study the effects of pesticides on different types of farms? And the effects of pesticides on bumblebees in small-scale experiments? This is a perfect PhD project for you!

REQUIREMENTS

- a MSc in biology (ecology), microbiology, plant sciences, ecotoxicology, veterinary medicine
- proven affinity with quantitative analysis and/or mathematical modelling
- experience with working in a laboratory
- excellent communication and writing skills
- a creative and collaborative personality
- have excellent command of English (native or near-native)

Postdoc position: "Understanding large-scale spatiotemporal distributions of macrozoobenthos in the Dutch Wadden Sea"

Published	Deadline	Location
23 Dec	14 Feb	't Horntje (Texel)

JOB DESCRIPTION

The department of Coastal Systems (COS) is looking for a Postdoc. We offer a postdoctoral position of 3 years on study of spatiotemporal variation in macrozoobenthos in the Dutch Wadden Sea. This project is part of ongoing research on understanding the spatial and temporal distributions of benthic communities in the Dutch Wadden Sea.

REQUIREMENTS

Applicants must have a PhD degree, or aim to submit their PhD thesis for assessment by spring 2021. A background in ecology, macrozoobenthos, experience with handling large data sets, and the analysis of spatiotemporal distributions are required. Because the successful candidate will have large amounts of spatiotemporal data available, strong statistical, analytical, and computational skills are critical. The successful candidate is also expected to have good collaborative skills and proven abilities to

PhD position - Food and land use system transformations in Europe:

Your qualities

We are seeking an enthusiastic and results-driven candidate with the following criteria:

- A successfully completed MSc degree in agricultural or business economics, with a focus on food systems; or
- Food system governance, with proven experience in sustainability;
- Strong teamwork skills for transdisciplinary research;
- Proficiency in both oral and written English;
- Analytical skills with experience and interest in data analysis;
- Regional knowledge (preferred): Affinity with food systems.



- A Master's degree in marine ecology/biology, oceanography or a closely related discipline
- Experience with cetacean and/or deep-sea cephalopod or fish ecology in the field and/or in the lab, in multi-disciplinary research settings
- Ability to grasp ecological concepts and perform integrative analysis from multiple data streams
- A demonstrated ability to work on programming software such as R, Python or Matlab
- Strong communication and writing skills in English
- You are a team player and well organized, but also able to work independently
- Affinity with field work and working/living in a team
- Driving license B
- Previous experience with one of more of the following techniques is an advantage: biologging, echo sounder, species-habitat association modelling (or comparable)

Programmeren en modelleren zijn biologische basisvaardigheden geworden

PhD Effects of pesticide mixtures on insects

Published	Deadline	Location
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Cursusinformatie



Biologische Modellen en Statistiek



Cursusinformatie

Inleiding

Algemene cursusinformatie

Studieplanning

Handige links

Basisprincipes van R >

Basiswiskunde >

Biologische modellen >

Statistiek >

Bijlagen >

Cursusinformatie > Algemene cursusinformatie

Algemene cursusinformatie

Alle praktische informatie over de cursus verzamelen we hier. Als je vragen hebt, stel die dan vooral, liefst tijdens de hoor- of werkcolleges, of in Teams in de channel 'Praktische vragen' zodat anderen er ook van kunnen profiteren. Je kunt de docenten ook bereiken via het e-mailadres

kwantitatieve.biologie@uu.nl.

Docenten

Cursuscoördinator

dr. Bram van Dijk, b.vandijk@uu.nl

Onderzoeksgroep Theoretische Biologie

H.R. Kruytgebouw, Padualaan 8, kamer N605

Eerstejaarscoördinator

Christa Eekhuis MSc., c.a.eekhuis@uu.nl (organisatie, blackboard en niet-inhoudelijke vragen)

Docenten

- dr. Bram van Dijk, b.vandijk@uu.nl

Inhoudsopgave

Docenten

Cursusonderdelen

Leerdoelen

Vaardigheden

De belangrijkste tip

Toetsing

Werkvormen

Groepsindeling

Teams

Blackboard

Studiematerialen

Aanwezigheidsplicht

Feedback en evaluatie

Cursusinformatie



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- Gedetailleerde informatie zie vind je op de website. **Lees deze in detail door!**

Werkvormen

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- **Direct** opgevolgd door een **werkcollege**
- Er is een aanzienlijk deel **zelfstudie**.
- Tijdens een **kort mini-project** (week 5) heb je deze zelfstudietijd zeer zeker nodig!

De belangrijkste tip: zorg dat je niet achter loopt!

Studenten die de stof goed bijhouden ronden deze cursus vaak goed af, zelfs als de stof door hen als pittig wordt ervaren!

Planning

Planning



Biologische Modellen en Statistiek

- Cursusinformatie v
- Inleiding
- Algemene cursusinformatie
- Studieplanning**
- Handige links
- Basisprincipes van R >
- Basiswiskunde >
- Biologische modellen >
- Statistiek >
- Bijlagen >

Cursusinformatie > Studieplanning

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Show entries

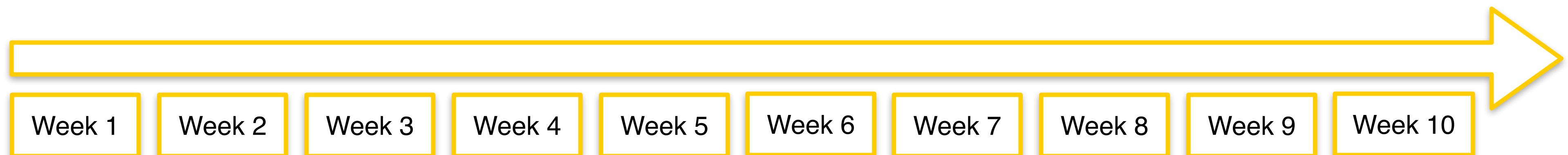
Search:

Wk	Deel	Datum	Dag	Tijd	Activiteit	Content	Hfst
1	R en basiswiskunde	03/02/2025	Maandag	9:00 - 10:45	Hoorcollege	Introductie cursus + Introductie programmeren	1
1	R en basiswiskunde	03/02/2025	Maandag	11:00 - 12:45	Werkcollege	R installeren + Rstudio	1
1	R en basiswiskunde	04/02/2025	Dinsdag	9:00 - 10:45	Hoorcollege	Basis R	2
1	R en basiswiskunde	04/02/2025	Dinsdag	11:00 - 12:45	Werkcollege	Basis R	2
1	R en basiswiskunde	04/02/2025	Dinsdag	13.15 - 17:00	Zelfstudie	Inleiding, algebra, breuken, exponenten	3 t/m 5
1	R en basiswiskunde	06/02/2025	Donderdag	9:00 - 10:45	Hoorcollege	Inleiding, algebra, breuken	3 t/m 5
1	R en basiswiskunde	06/02/2025	Donderdag	11:00 - 12:45	Werkcollege	Inleiding, algebra, breuken	3 t/m 5
1	R en basiswiskunde	06/02/2025	Donderdag	13.15 - 17:00	Zelfstudie	Logaritmen, asymptoten, limieten, afgeleiden, schetsen	6 t/m 9

Showing 1 to 8 of 48 entries

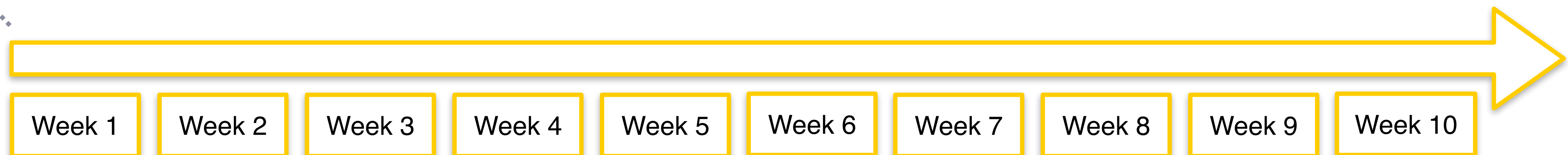
Previous 2 3 4 5 6 Next

Tijdslijn



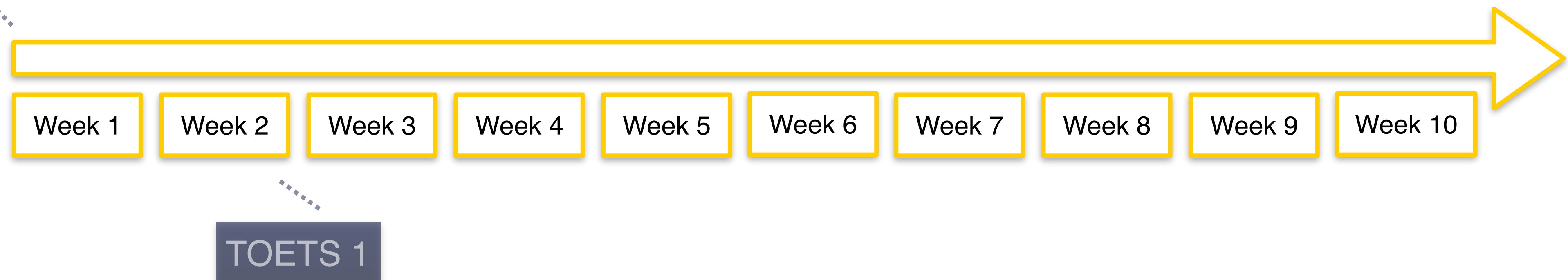
Tijdslijn

1. Basis van 'R' en wiskunde (eerste twee weken)



Tijdslijn

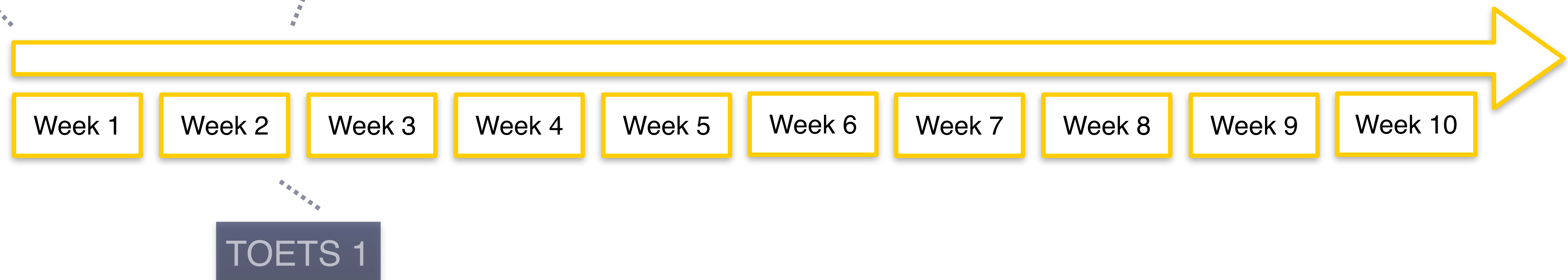
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Tijdslijn

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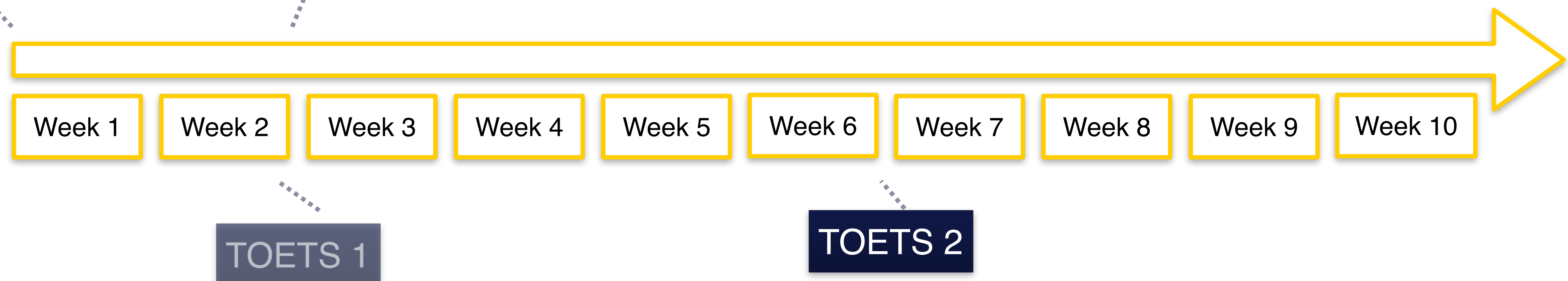
2. Biologische Modellen
(week 3 t/m 6)



Tijdslijn

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2. Biologische Modellen
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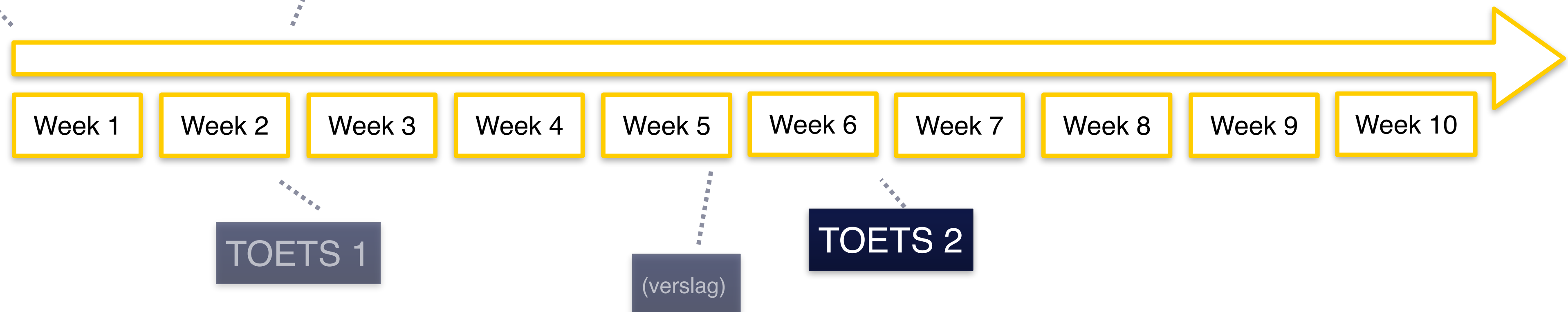
Tijdslijn

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(week 3 t/m 6)

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Tijdslijn

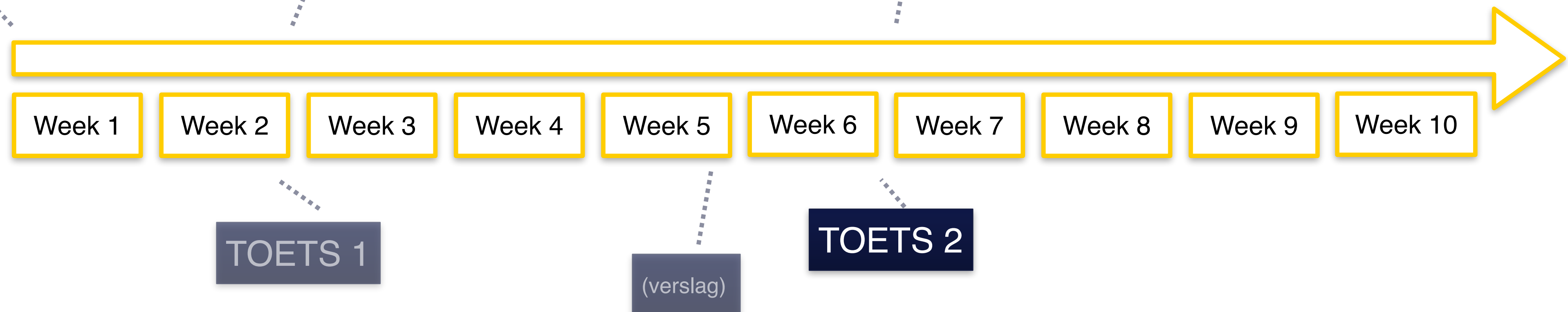
1. Basis van 'R' en wiskunde
(eerste twee weken)

2. Biologische Modellen

(week 3 t/m 6)

3. Biologische Modellen

(week 7 t/m 10)



Tijdslijn

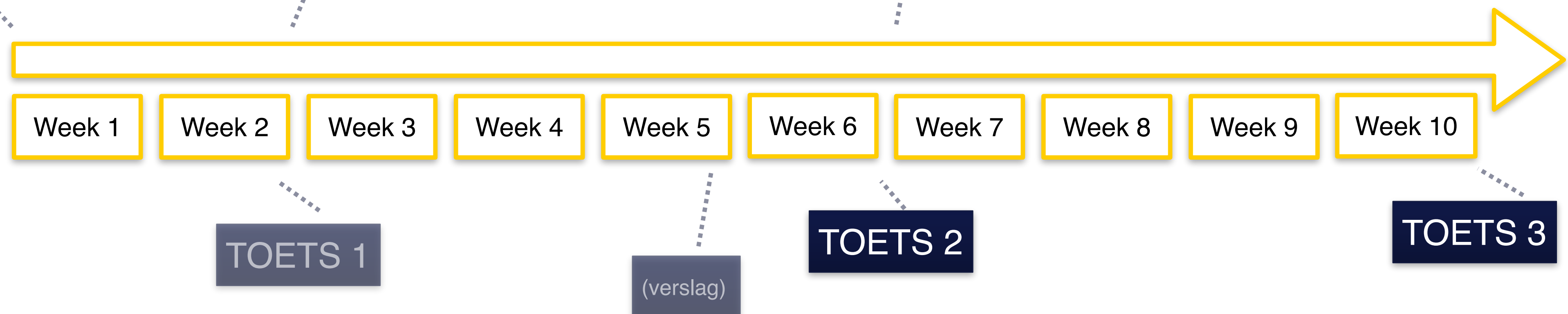
1. Basis van 'R' en wiskunde
(eerste twee weken)

2. Biologische Modellen

(week 3 t/m 6)

3. Biologische Modellen

(week 7 t/m 10)



Toetsing

Evaluatie	Beschrijving	Weging
Deeltoets I	Basisprincipes van R en Basiswiskunde	20%
Deeltoets II	Biologische Modellen	35%
Verslag	Mini-project tijdens 'Biologische Modellen'	10%
Deeltoets III	Statistiek	35%

Alle cijfers worden op 1 decimaal afgerond, en **alle ondergenoemde regels gelden voor de afgeronde cijfers.**

Voor de **deeltoetsen** moet minimaal een 5 gehaald worden. Is je cijfer lager dan een 5,5, dan mag je een **deeltoets herkansen**.

Om een eindcijfer te krijgen moet het **verslag ingeleverd** zijn, en **mag niet meer dan 25% van de werkcolleges zijn gemist**. Je moet je dan wel even afmelden, wat kan met [dit formulier](#).

Het **eindcijfer** moet minimaal een 5,5 zijn. In lijn met de OER: alleen een herkansing als het **eindcijfer tussen 4,0 en 5,5** zijn (let op: deeltoetsen hoeven niet hoger dan een 4,0 te zijn!). Er wordt in één zitting een herkansingsmoment aangeboden voor alle deeltoetsen die herkanst mogen worden.

Belang van pen en papier

Belang van pen en papier



The screenshot shows the 'Studieplanning' (Study Planning) page for the BMS course. The page includes a navigation menu on the left with 'Cursusinformatie' and 'Inleiding'. The main content area features a search bar, a 'Show 8 entries' dropdown, and a search input field. Below these elements is a table header with columns: 'Wk', 'Deel', 'Datum', 'Dag', 'Tijd', 'Activiteit', 'Content', and 'Hfst'. The table body is partially visible, showing the first row of the planning schedule.

Belang van pen en papier



**Biologische
Modellen en Statistiek**

Cursusinformatie > Studieplanning

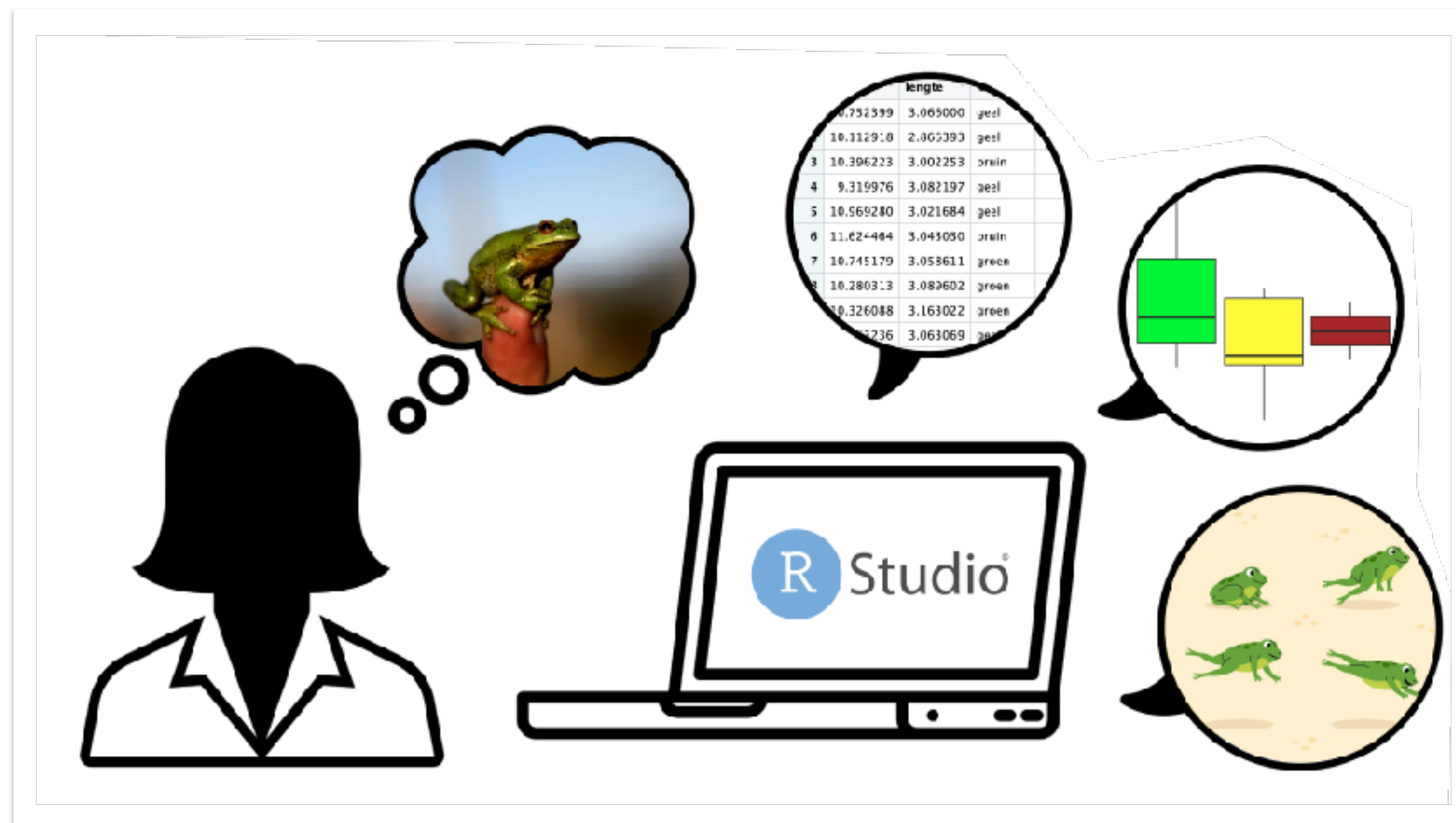
Studieplanning

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Show entries

Search:

Wk	Deel	Datum	Dag	Tijd	Activiteit	Content	Hfst
1							
2							
3							
4							
5							
6							
7							
8							



Belang van pen en papier



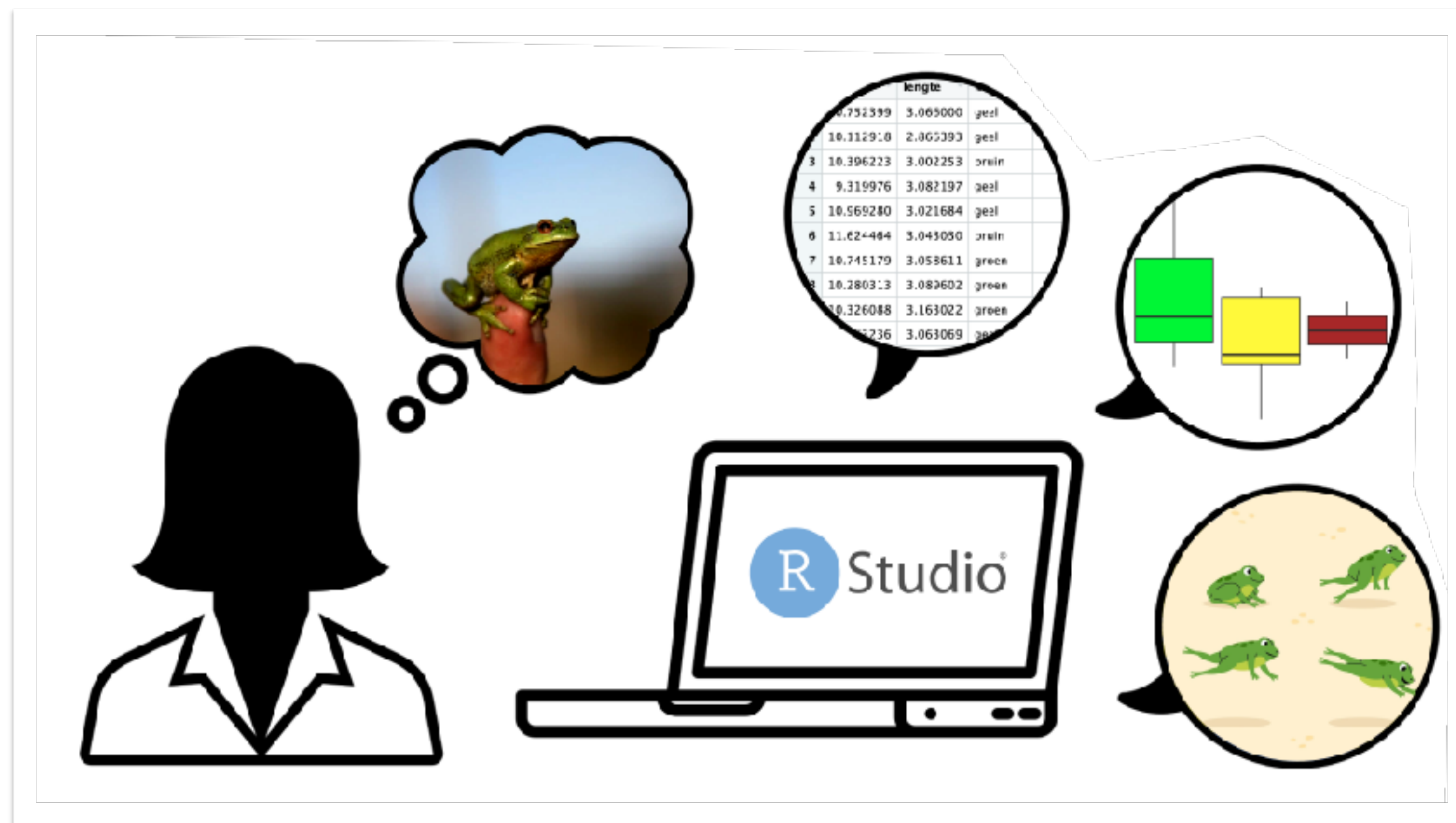
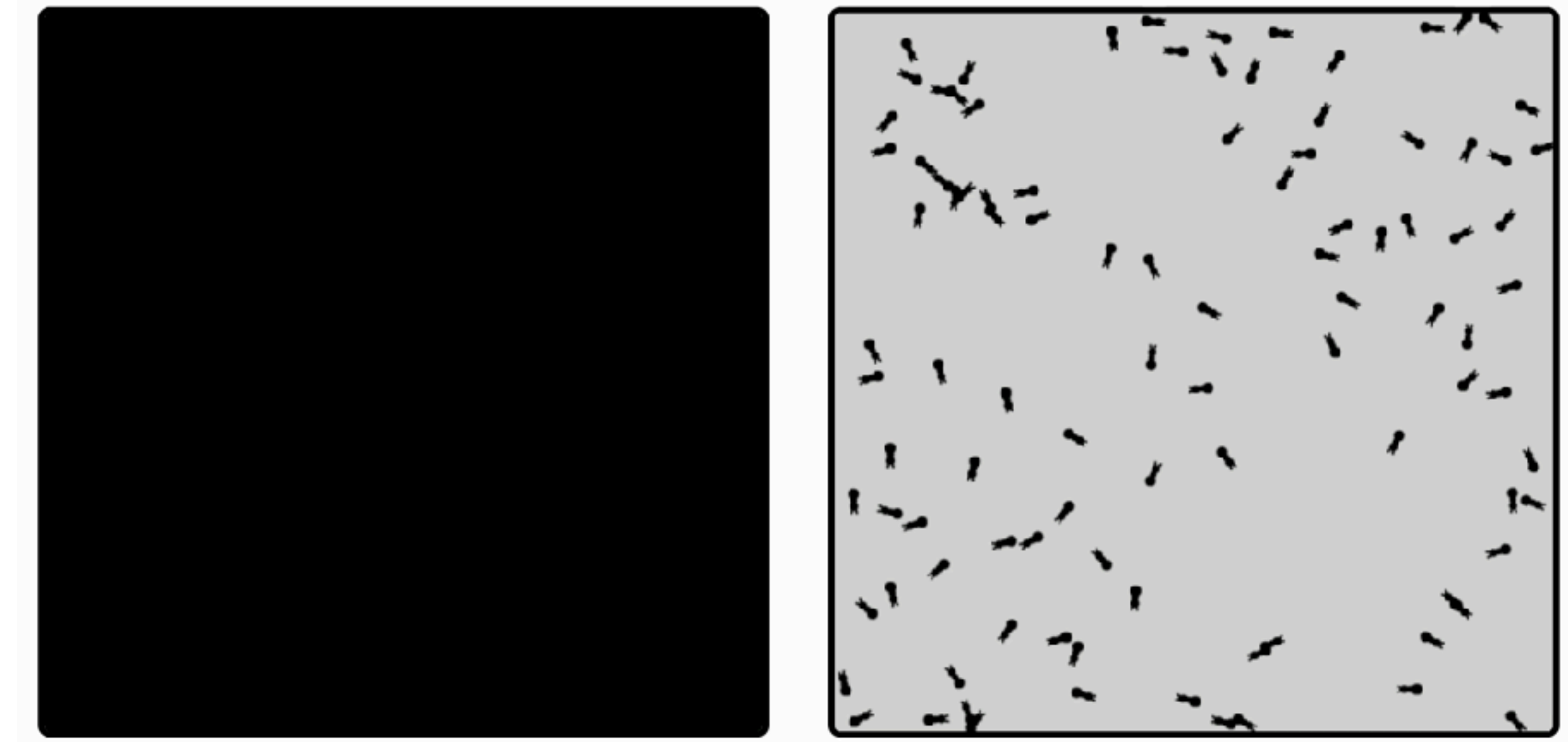
BMS
Biologische Modellen en Statistiek

Cursusinformatie > Studieplanning
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Belang van pen en papier

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Paper Notebooks vs. Mobile Devices: Brain Activation Differences During Memory Retrieval

 Keita Umejima¹  Takuya Ibaraki²  Takahiro Yamazaki²  Kuniyoshi L. Sakai^{1*}

¹ Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo, Tokyo, Japan

² NTT Data Institute of Management Consulting, Inc., Tokyo, Japan

It remains to be determined how different inputs for memory-encoding, such as the use of paper notebooks or mobile devices, affect retrieval processes. We compared three groups of participants who read dialogues on personal schedules and wrote down the scheduled appointments on a calendar using a paper notebook (Note), an electronic tablet (Tablet), or a smartphone (Phone). After the retention period for an hour including an interference task, we tested recognition memory of those appointments with visually presented questions in a retrieval task, while scanned with functional magnetic resonance imaging. We obtained three major results. First, the duration of writing down schedules was significantly shorter for the Note group than the Tablet and Phone groups, and accuracy was much higher for the Note group in easier (i.e., more straightforward) questions. Because the input methods were equated as much as possible between the Note and Tablet groups, these results indicate that the cognitive processes for the Note group were deeper and more solid. Second, brain activations for all participants during the retrieval phase were localized in the bilateral hippocampus, precuneus, visual cortices, and language-related frontal regions, confirming the involvement of verbalized memory retrieval processes for appointments. Third, activations in these regions were significantly higher for the Note group than those for the Tablet and Phone groups. These enhanced activations for the Note group could not be explained by general cognitive loads or task difficulty, because overall task performances were

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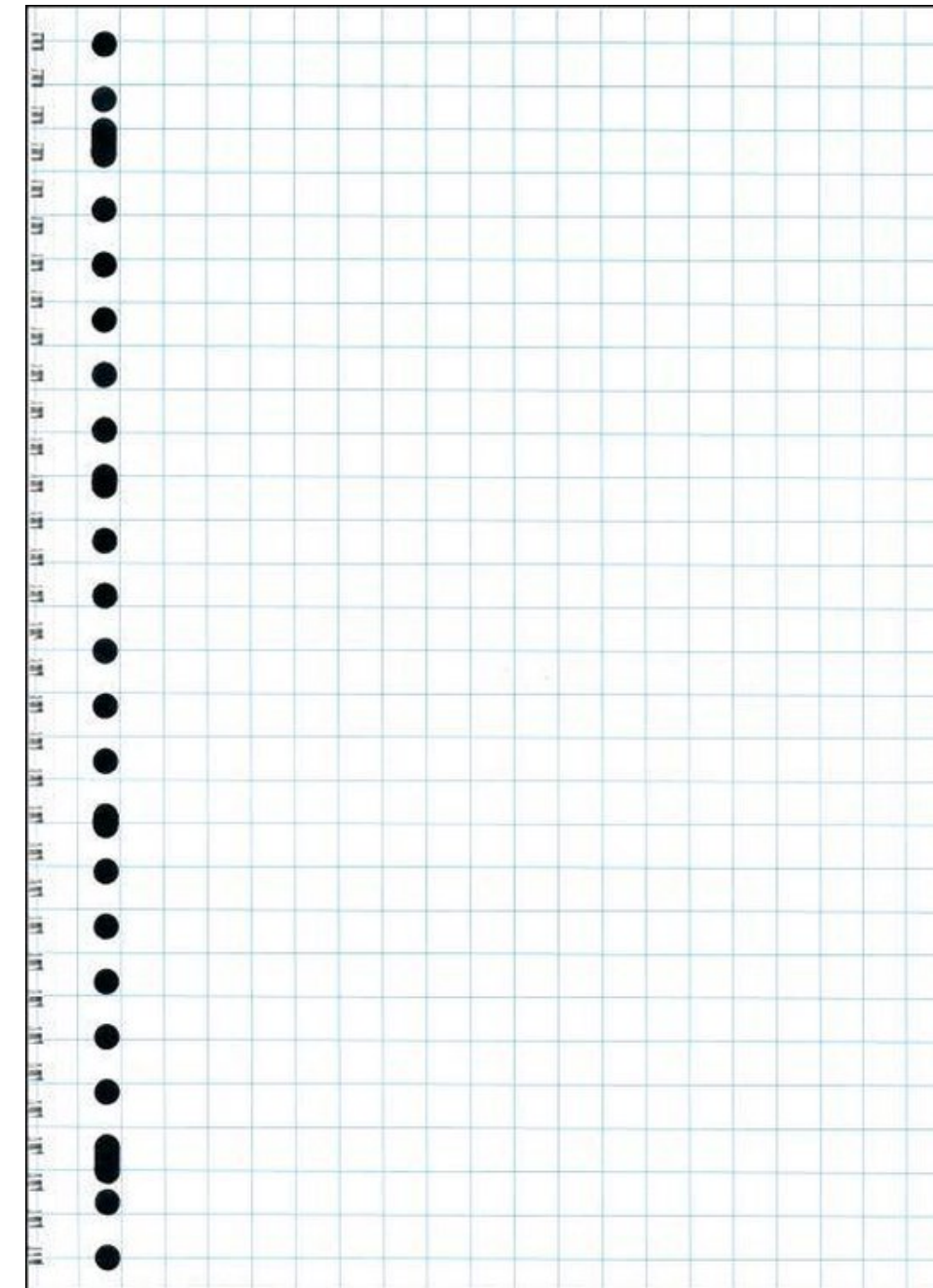
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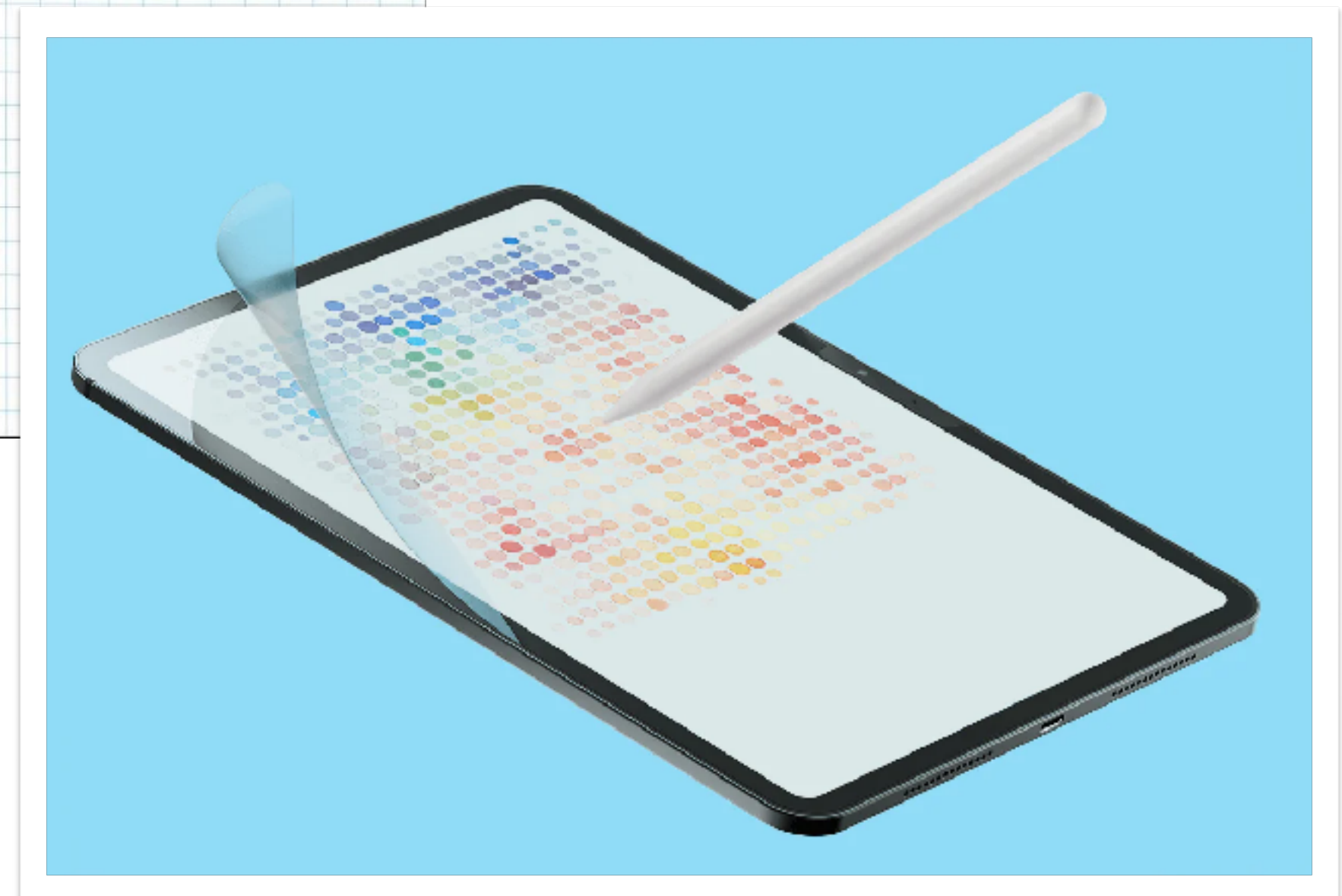
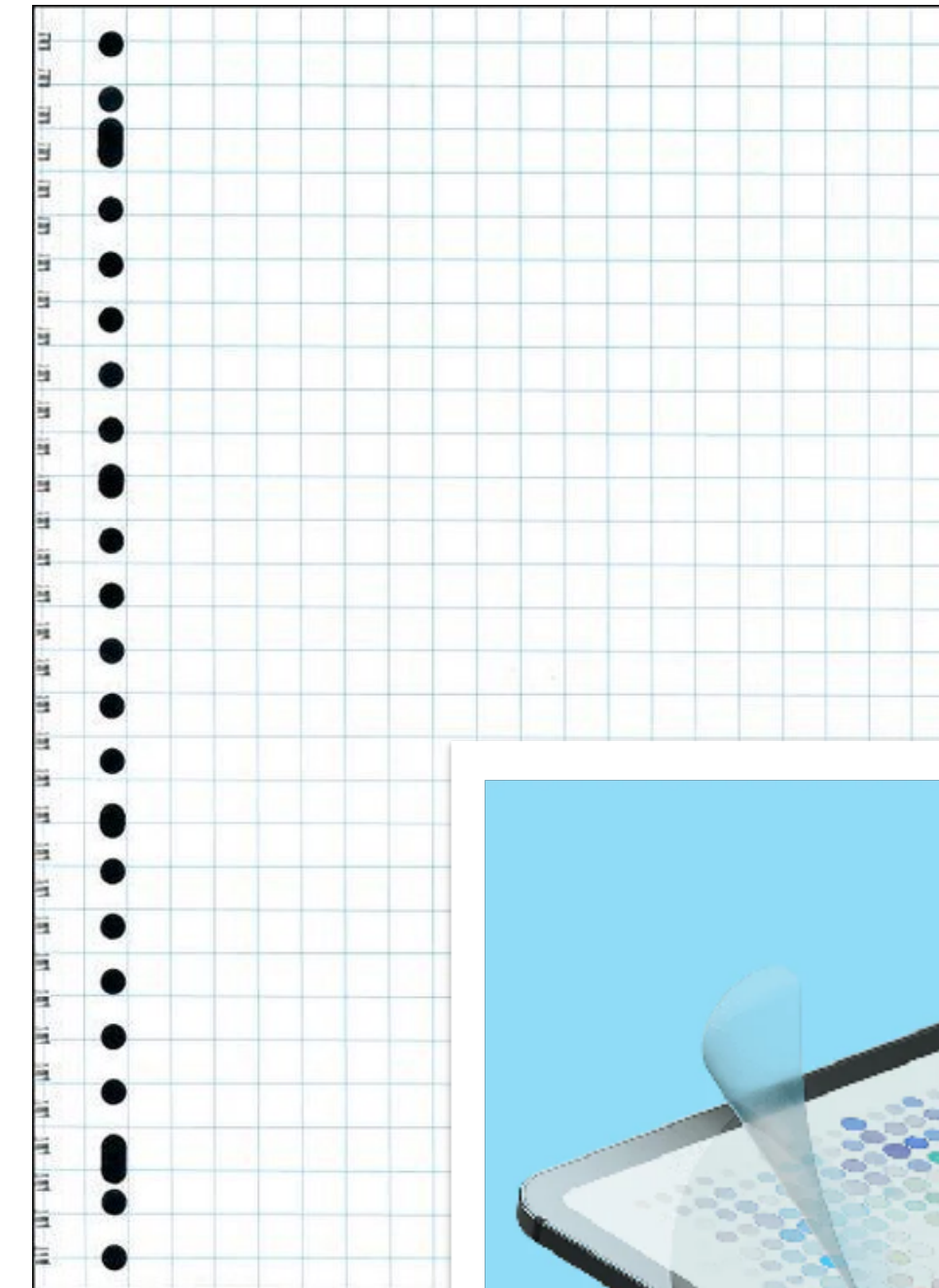
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Minder “uit je hoofd leren”



Minder “uit je hoofd leren”



Rekenregel	Voorbeeld
$a^n \cdot a^m = a^{n+m}$	$2^2 \cdot 2^3 = 2^{2+3} = 2^5$
$a^n \div a^m = a^{n-m}$ als $a \neq 0$	$2^5 \div 2^2 = 2^{5-2} = 2^3$
$(a^n)^m = a^{nm}$	$(2^2)^2 = 2^4$
$(a^n \cdot b^m)^q = a^{nq} \cdot b^{mq}$	$(2^3 \cdot 3^4)^2 = 2^6 \cdot 3^8$
$a^{-n} = 1/a^n$	$4^{-2} = 1/4^2$
$a^0 = 1$	$2^0 = 1$

Minder “uit je hoofd leren”



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Bij **alle drie de deeltaetsen**, mogen jullie één A4tje (voor én achterkant) **volschrijven** (printen is niet toegestaan!) en meenemen als “spiekbriefje”

Meer spiekbriefjes!

Meer spiekbriefjes!

Base R Cheat Sheet

Getting Help

Accessing the help files

?mean
Get help of a particular function.

help.search('weighted mean')
Search the help files for a word or phrase.

help(package = 'dplyr')
Find help for a package.

More about an object

str(iris)
Get a summary of an object's structure.

class(iris)
Find the class an object belongs to.

Using Packages

install.packages('dplyr')
Download and install a package from CRAN.

Vectors		
Creating Vectors		
<code>c(2, 4, 6)</code>	2 4 6	Join elements into a vector
<code>2:6</code>	2 3 4 5 6	An integer sequence
<code>seq(2, 3, by=0.5)</code>	2.0 2.5 3.0	A complex sequence
<code>rep(1:2, times=3)</code>	1 2 1 2 1 2	Repeat a vector
<code>rep(1:2, each=3)</code>	1 1 1 2 2 2	Repeat elements of a vector
Vector Functions		
sort(x) Return x sorted.	rev(x) Return x reversed.	
table(x) See counts of values.	unique(x) See unique values.	
Selecting Vector Elements		
By Position		
x[4]	The fourth element.	

Programming	
For Loop	While Loop
<pre>for (variable in sequence){ Do something }</pre>	<pre>while (condition){ Do something }</pre>
Example	Example
<pre>for (i in 1:4){ j <- i + 10 print(j) }</pre>	<pre>while (i < 5){ print(i) i <- i + 1 }</pre>
If Statements	Functions
<pre>if (condition){ Do something } else { Do something different }</pre>	<pre>function_name <- function(var){ Do something return(new_variable) }</pre>
Example	Example
<pre>if (i > 3){ print('Yes') } else { print('No')</pre>	<pre>square <- function(x){ squared <- x*x }</pre>

Meer spiekbriefjes!

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Find the class an object belongs to.

Using Packages

`install.packages('dplyr')`

Download and install a package from CRAN.

Vectors

Creating Vectors

<code>c(2, 4, 6)</code>	2 4 6	Join elements into a vector
<code>2:6</code>	2 3 4 5 6	An integer sequence
<code>seq(2, 3, by=0.5)</code>	2.0 2.5 3.0	A complex sequence
<code>rep(1:2, times=3)</code>	1 2 1 2 1 2	Repeat a vector
<code>rep(1:2, each=3)</code>	1 1 1 2 2 2	Repeat elements of a vector

Vector Functions

sort(x) Return x sorted.	rev(x) Return x reversed.
table(x) See counts of values.	unique(x) See unique values.

Selecting Vector Elements

By Position

`x[4]` The fourth element.

```
for (variabl
  Do someth
}
```

```
for (i in 1:
  j <- i +
  print(j)
}
```

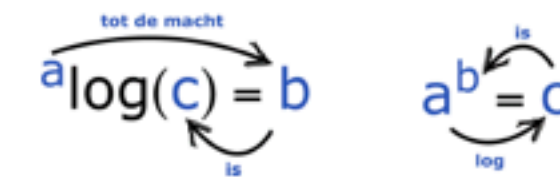
```
if (conditio
  Do someth
} else {
  Do someth
}
```

```
if (i > 3){
  print('Ye
} else {
  print('No
```

Breuken

Rekenregel	Voorbeeld
$\frac{a}{cb} = \frac{a}{b}$	$\frac{23}{24} = \frac{3}{4}$
$\frac{a/c}{b/c} = \frac{a}{b}$	$\frac{3/2}{4/2} = \frac{3}{4}$
$\frac{a}{b} \cdot \frac{c}{d} = \frac{ac}{bd}$	$\frac{1}{2} \cdot \frac{3}{4} = \frac{1 \cdot 3}{2 \cdot 4} = \frac{3}{8}$
$a \div \frac{b}{c} = a \cdot \frac{c}{b} = \frac{ac}{b}$	$2 \div \frac{3}{4} = 2 \cdot \frac{4}{3} = \frac{2 \cdot 4}{3} = \frac{8}{3}$
$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$	$\frac{1}{2} \div \frac{3}{4} = \frac{1}{2} \cdot \frac{4}{3} = \frac{4}{6}$
$\frac{a}{b} + \frac{c}{b} = \frac{a+c}{b}$	$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$
$\frac{a}{b} + \frac{c}{d} = \frac{ad}{bd} + \frac{bc}{bd} = \frac{ad+bc}{bd}$	$\frac{1}{2} + \frac{3}{4} = \frac{1 \cdot 4}{2 \cdot 4} + \frac{3 \cdot 3}{2 \cdot 4} = \frac{4+6}{8} = \frac{10}{8}$

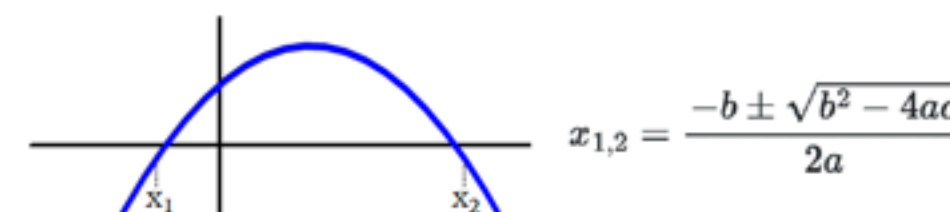
Exponenten en logaritmen



Rekenregel	Voorbeeld
$a^n \cdot a^m = a^{n+m}$	$2^2 \cdot 2^3 = 2^{2+3} = 2^5$
$a^n \div a^m = a^{n-m}$ als $a \neq 0$	$2^5 \div 2^2 = 2^{5-2} = 2^3$
$(a^n)^m = a^{nm}$	$(2^2)^2 = 2^4$
$(a^n \cdot b^m)^q = a^{nq} \cdot b^{mq}$	$(2^3 \cdot 3^4)^2 = 2^6 \cdot 3^8$
$a^{-n} = 1/a^n$	$4^{-2} = 1/4^2$
$a^0 = 1$	$2^0 = 1$

Rekenregel	Voorbeeld
${}^b \log b^a = a$	${}^{10} \log 1000 = {}^{10} \log 10^3 = 3$
$\log a + \log b = \log ab$	$\log 100 + \log 10 = \log 1000$
$\log a - \log b = \log a/b$	$\log 8 - \log 2 = \log 8/2 = \log 4$
$a \cdot \log b = \log b^a$	$7 \cdot \log 5 = \log 5^7$
${}^a \log a = 1$	${}^2 \log 2 = 1$
${}^a \log c = b \Rightarrow a^b = c$	${}^2 \log 8 = 3 \Rightarrow 2^3 = 8$

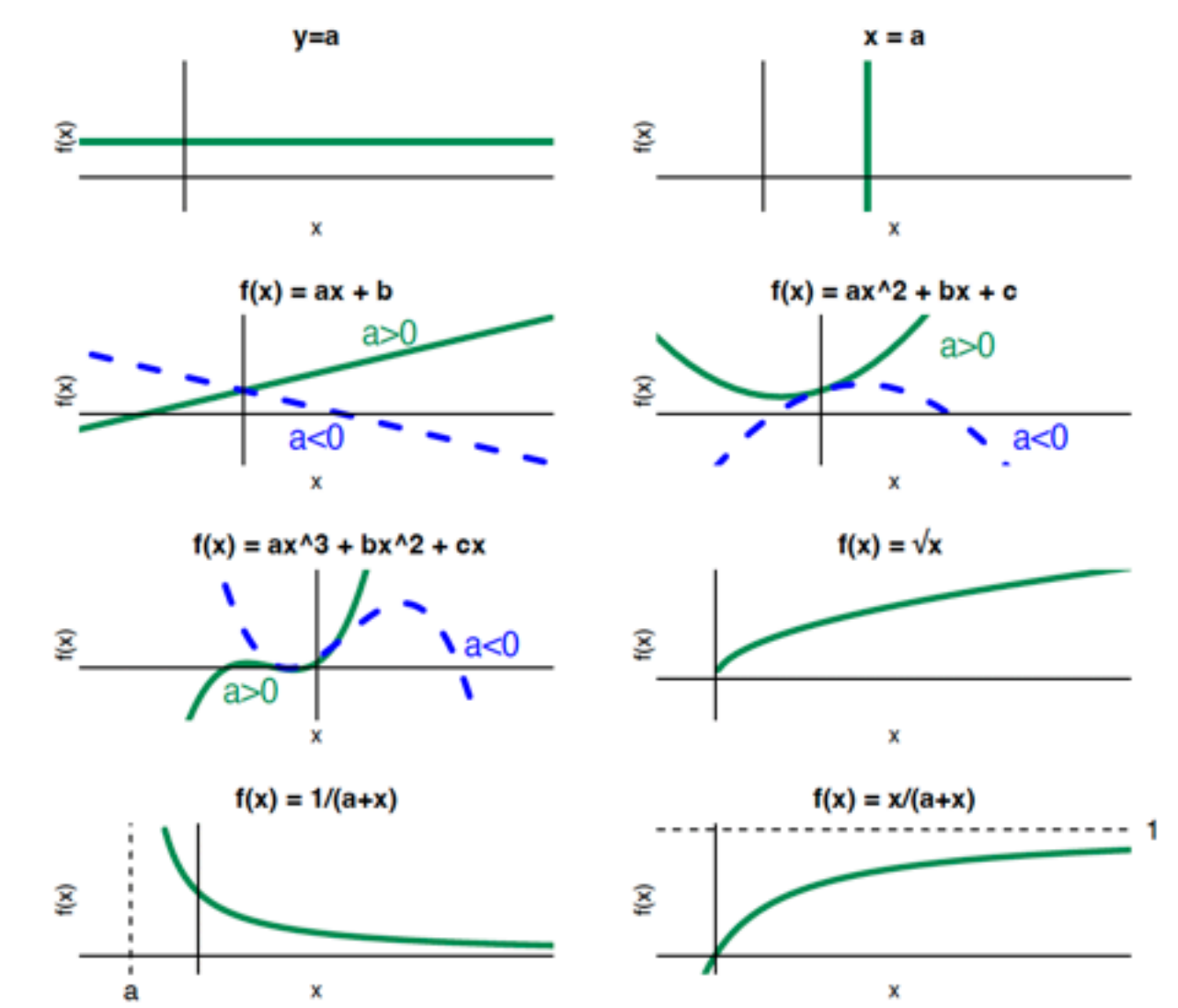
ABC-formule



Afgeleide van functies

Functie	Afgeleide	$f(x)$	$f'(x)$
a	0	6	0
ax	a	$7x$	7
ax^b	$b \cdot ax^{b-1}$	$8x^3$	$24x^2$
$c \cdot f(x)$	$c \cdot f'(x)$	$2x^{13}$	$2 \cdot 13x^{12} = 26x^{12}$
$f(x) + g(x)$	$f'(x) + g'(x)$	$x^4 + 4x$	$4x^3 + 4$
e^x	e^x	e^x	e^x
ae^{bx}	$b \cdot ae^{bx}$	$\frac{1}{2} \cdot \pi\sqrt{2} \cdot e^{2x}$	$\pi\sqrt{2} \cdot e^{2x}$
$e^{f(x)}$	$f'(x) \cdot e^{f(x)}$	e^{2x^2-x}	$(4x-1) \cdot e^{2x^2-x}$
$a^{f(x)}$	$\ln(a) \cdot f'(x) \cdot a^{f(x)}$	5^{4x-1}	$\ln(5) \cdot 4 \cdot 5^{4x-1}$
$\ln(x)$	$\frac{1}{x}$	$\ln(x)$	$\frac{1}{x}$
$\ln(ax) = \ln(a) + \ln(x)$	$\frac{1}{x}$	$\ln(4x) = \ln(4) + \ln(x)$	$\frac{1}{x}$
$f(x) \cdot g(x)$	$f'(x) \cdot g(x) + f(x) \cdot g'(x)$	$(x^2-4)(x^3+2x+3)$	$5x^4 - 6x^2 + 6x - 8$
$\frac{f(x)}{g(x)}$	$\frac{g(x) \cdot f'(x) - f(x) \cdot g'(x)}{(g(x))^2}$	$\frac{4x+1}{x^2+1}$	$\frac{-4x^2-2x+4}{(x^2+1)^2}$

Grafieken van functies





**Kwantitatieve Biologie
was eigenlijk best
makkelijk!**

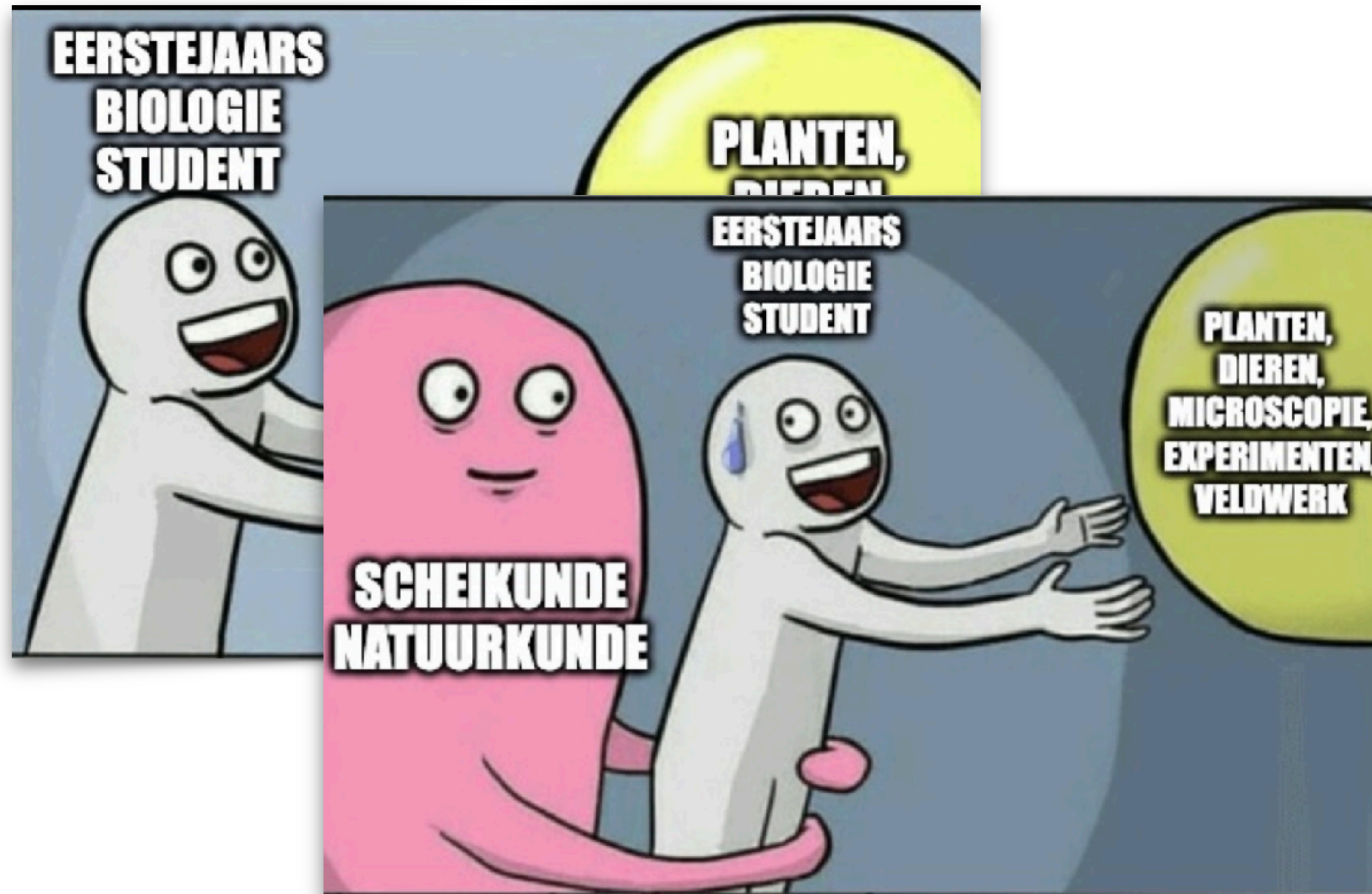


**Kwantitatieve Biologie
was eigenlijk best
makkelijk!**

**Ik maak me nu al
zorgen over
Kwantitatieve Biologie**









Comfortabel worden met wiskunde en computers



Wiskundeangst

Wiskundeangst



☰ Menu | **nrc** 

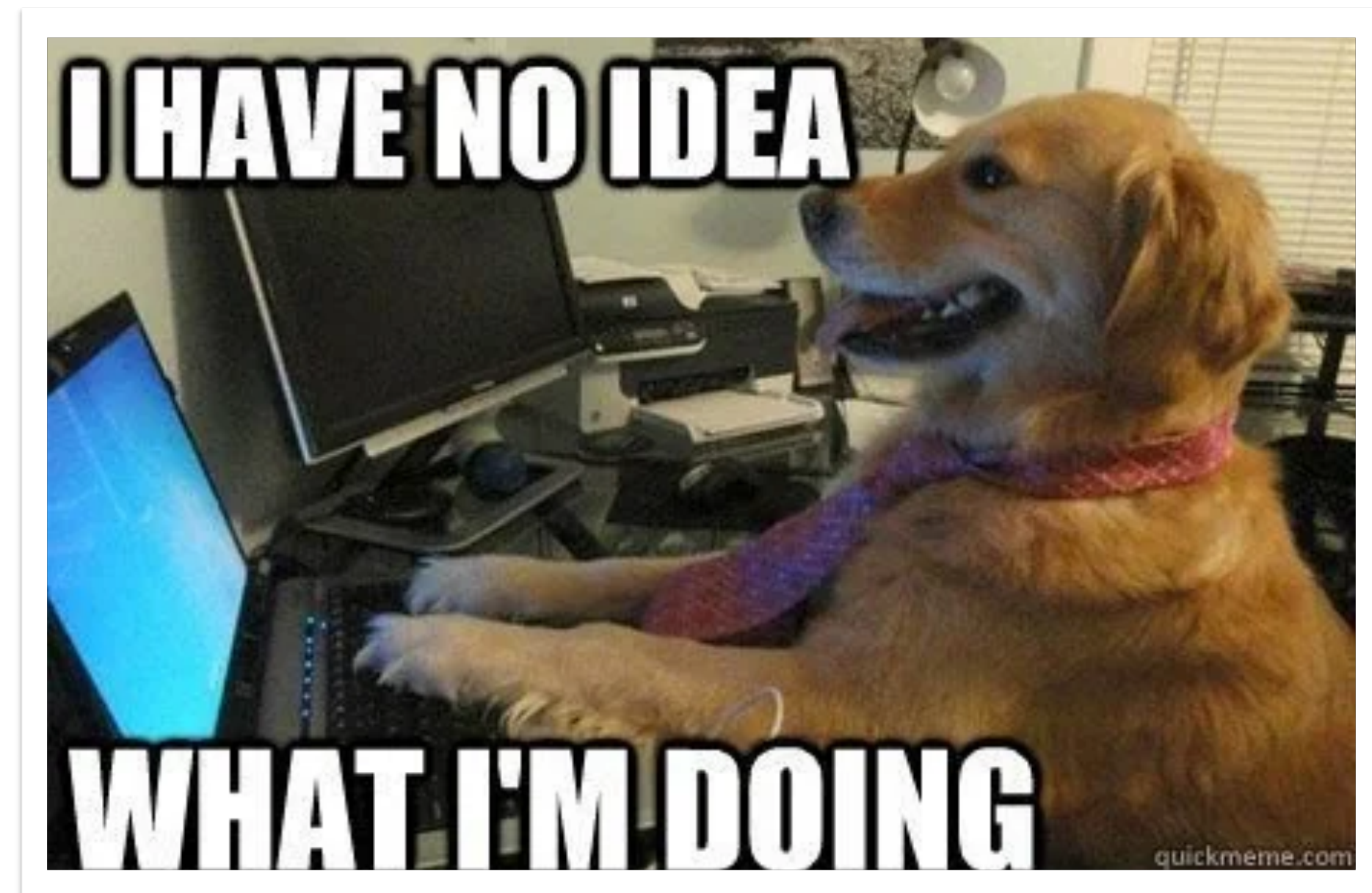
 Luister naar
39:01

Kan dat, van je wiskundeangst afkomen?

Faalangst Journalist *Brigit Kooijman* ging, 45 jaar na dato, op bijles bij haar oude wiskundeleraar om éindelijk te begrijpen of er zoiets is als de wortel van min drie. En waarom vindt zij, net als zoveel anderen, wiskunde eigenlijk zo moeilijk?

Misschien ziet dit...

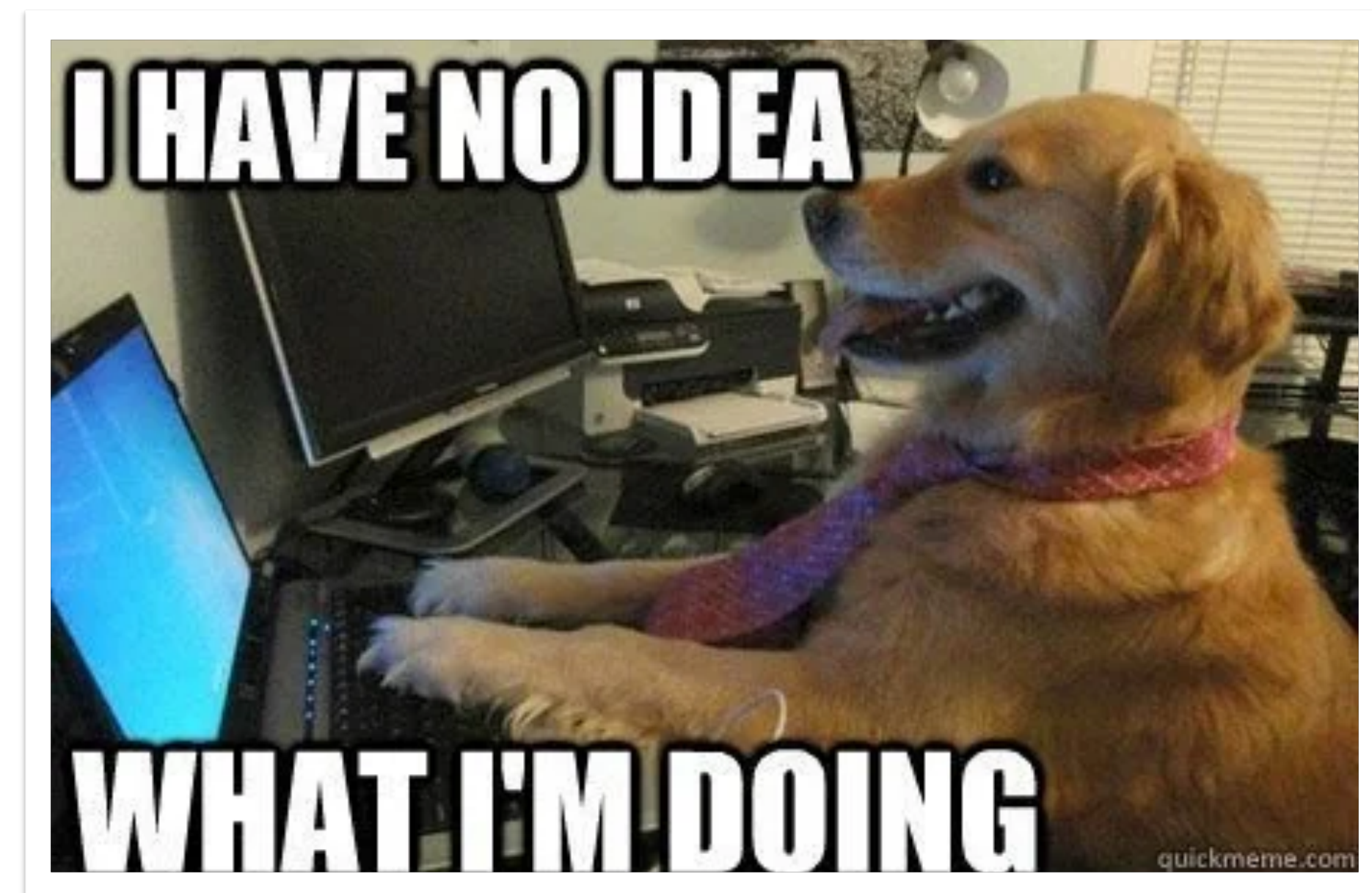
$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$



Misschien ziet dit...

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

... er zo uit voor je.



Misschien ziet dit...

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

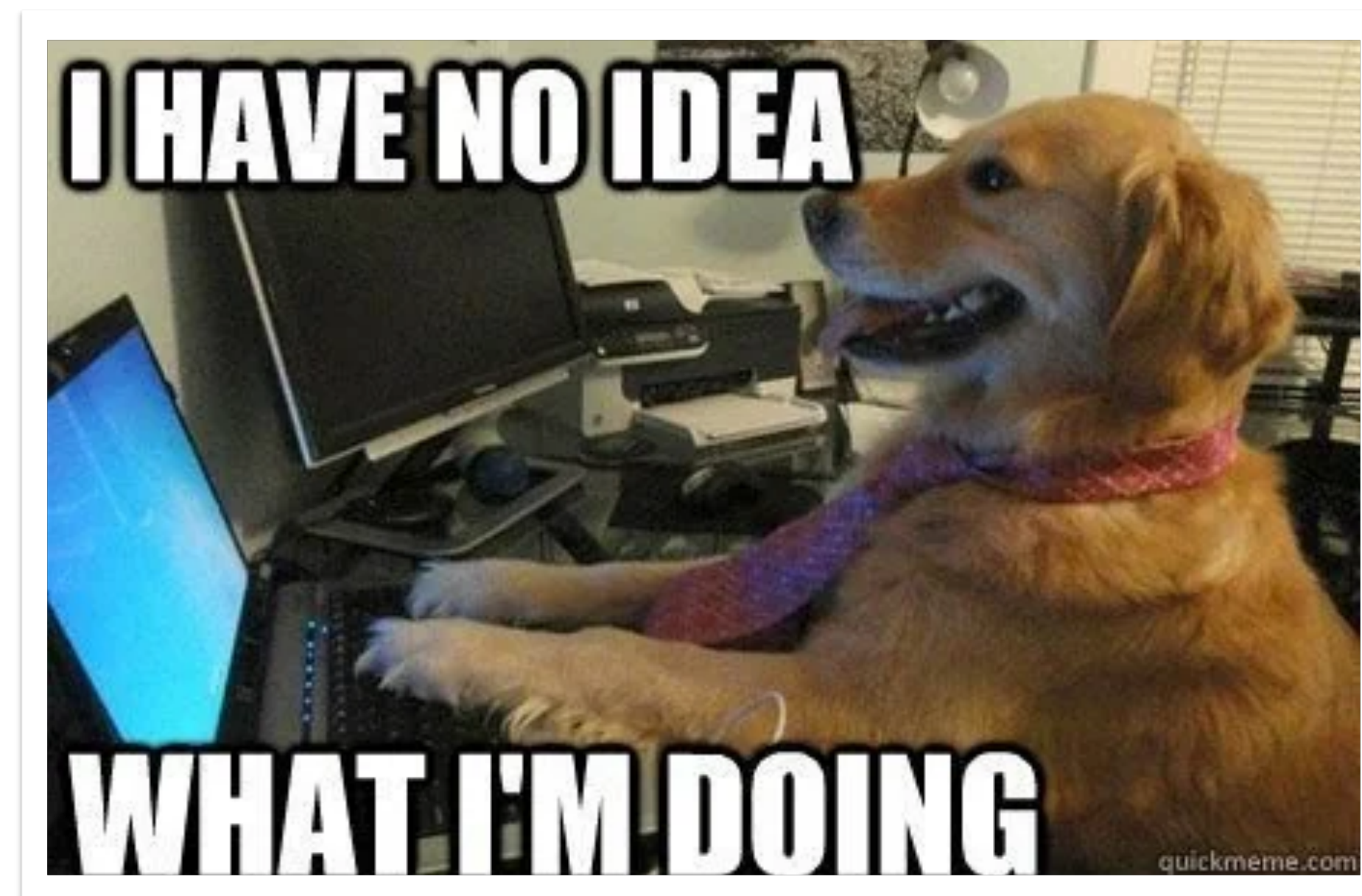
... er zo uit voor je.

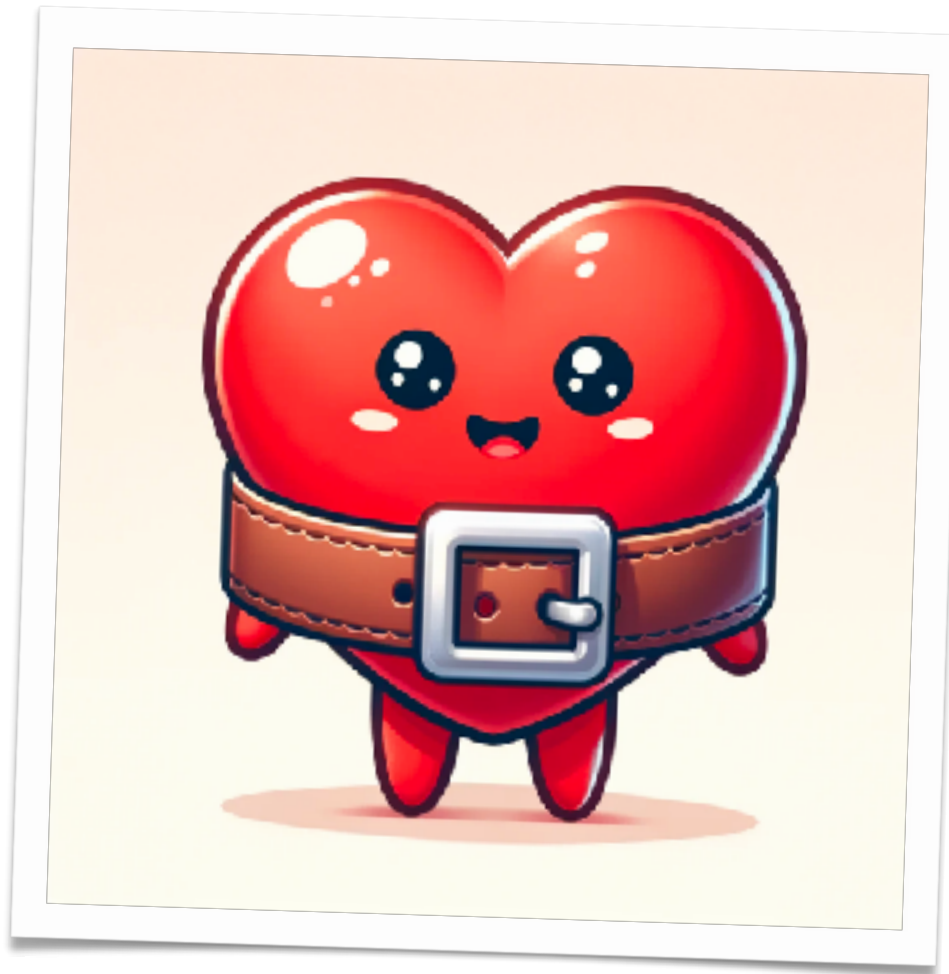


```

p <- 400 # hoeveelheid paracetamol
d <- 0.7 # afname (d van decay)

for(i in 1:100){
  if(runif(1)<0.1){ # is willekeurig getal (tuss
    p[i] <- p[i] + 400
  }
  p[i+1] <- p[i]*d
}
plot(p, type='o')
  
```





Dit vak wordt **door** en **voor** biologen gegeven.
Je moet vooral meedoen, oefenen,
en **kritisch blijven denken**.

Vragen?