Gene interactions



CREDITS

A POLYMAT game, part of Zientzia Jolasak.

Design Beñat Olave (POLYMAT). Game mechanics inspired by a traditional code-breaking game.

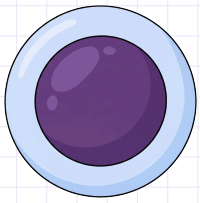
Science Based on Sanz Larrarte et al., *iScience* 29, 116619 (2026), from Tecnun (University of Navarra), and its first version (arXiv:2509.06891). The chains in free play are made up for the game. The orders in the cases and what each gene does come from earlier studies. The article or its first version cites them.

Illustrations Generated with AI (Gemini).

02/45

THE B LYMPHOCYTE

What is a B lymphocyte?



B lymphocytes are white blood cells, part of your body's defences.

They are round, and almost all of the inside is the nucleus, where the genes are.

Each B lymphocyte recognises one kind of foreign thing, such as a piece of a virus.

03/45

THE GENES

Genes: a set of instructions

A gene is an instruction for the cell.

It can be on, and the cell uses it, or off, and the cell doesn't.



→ **switches on**

⊣ **switches off**

Some genes give orders to others: "switch on!" or "switch off!"

Those orders, together with signals from outside, help the lymphocyte turn into a factory.

04/45

THE CELL

If you are the cell

Read the CASE aloud. Secretly look at its other side and put it in its place on the board.

Compare by number: link 1 with 1, link 2 with 2.

Same gene in the same place: ✔. A gene in the chain, but elsewhere: ⇿. A gene that isn't in the chain: nothing.

In the boxes, put the ✔ first and then the ⇿, without saying which ones. If there are none, say so aloud.

If there are as many ✔ as links, case solved! Say it aloud.

05/45

THE TEAM

How to investigate

One person is the cell: they read the CASE aloud and secretly look at its other side.

Everyone else investigates: taking turns, one person fills the next row, one gene from the case per link, no repeats.

The cell puts one ✔ per gene in place and one ⇿ per gene in the chain, but elsewhere.

Each row is an experiment and stays on the board. Your score is the number of the row with as many ✔ as the case has links.

Whoever filled the last row turns over the case's REWARD and reads it aloud. Then a new person becomes the cell.

06/45

FREE PLAY

Turn the gene tokens over: on the side with no name, they are just symbols.

The cell puts 2 or 3 different symbols in the CASE's place, lined up with the links. The cell hides them under the cover card turned sideways and says how many.

Play it like a case, with no data clue. When the board is full, clear row 1 and carry on: it becomes row 9, and so on.

Duel: each player or team is the cell once. Whoever cracks the chain in fewer rows wins.

The chains in free play are made up: they are not real orders.

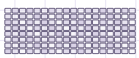
07/45

METHOD

How Tecnun did it

1  **2×2×2×2×2×2 = 64**

Each gene can be on or off: with 6 genes, a cell can be in 64 different states.

2 

Tecnun looked at data from more than 28,000 cells and noted in a table how many were in each state.

3 

With many genes, that table would be huge. So it is stored as a chain of small pieces, one per gene: a chain of data, not of orders.

08/45

LET'S TALK

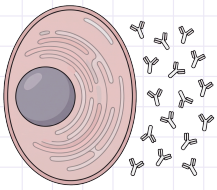
Tecnun didn't measure those cells: they took public data, open to everyone, and studied it with a new method. In every game, you also started with a clue from public data.



09/45

THE B LYMPHOCYTE

Why does it matter?



Antibodies stick to viruses and bacteria and help get rid of them.

Vaccines teach your B lymphocytes to recognise a germ without you getting ill.

If the real one comes later, your defences already know it.

CREDITS

Funded by

EUSKO JAURLARITZA GOBIERNO VASCO
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HOW TO PLAY

labur.eus/geneak

2-5 players · ages 12+ · about 20 minutes per game

One game is three cases: 1 to 3, or 4 to the final challenge.

At the end of each game, read METHOD and LET'S TALK.

THE TEAM

What the clues tell you

With 2 links

Case solved!

Both are there, but the wrong way round.

One is in place. The other is not in this chain.

One is there, but in the other place. The other is not in this chain.

Neither of them is in this chain.

The clues say how many, not which ones. Think with all of them at once.

If you get stuck, find the case's possible chains and cover the impossible ones with spare tokens.

THE CELL

Example

? ? ?

① ② ③

① B - A - D

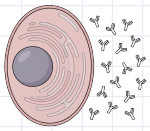
The hidden chain is A, B, C.

Experiment: B, A, D. None is in the right place. B and A are in the chain, but elsewhere.

The cell puts ⇔ ⇔. D is not in this chain.

If the team gets stuck, check your clues and correct any that are wrong.

FROM LYMPHOCYTE TO FACTORY



When a B lymphocyte finds what it recognises and gets other alarm signals, it is activated.

Then it multiplies and tries out small changes in its antibodies.

Then some of those cells change jobs.

They become plasma cells: factories that release huge numbers of antibodies, all the same.

During that change, some genes switch on and others switch off.

LET'S TALK

1. Public data gave you a clue without using up any experiments. Why would a lab want to share its data? And why might it not want to?

2. The cells in the data come from people. Who should decide what they are used for?

3. In a lab, every experiment uses samples, money and energy. When is one more worth doing?

METHOD

4

By putting pieces together, you can look at any three genes at once. That is how they saw that IRF4, PRDM1 and PAX5 work as a team.

5



Storing the table in pieces is an idea that comes from quantum physics. But it was all worked out on an ordinary computer, not a quantum one.



CASE 3

The switch

Which order makes the lymphocyte stop being a B lymphocyte?

Clue from Tecnun's data: PRDM1 is related to another gene in this case. In the game, that means it is in the chain.

Genes in this case

REL · PRDM1 · IRF4 · AICDA · PAX5

2 links

1 — 2

12/45

FINAL CHALLENGE

The real chain

Now the chain has three genes.

Tecnun's data: IRF4, PRDM1 and PAX5 work as a team, so they are in the chain. The data don't say who gives the order.

Genes in this case

REL · RELA · PRDM1 · IRF4 · AICDA · PAX5

3 links

1 — 2 — 3

15/45

REWARD · CASE 3

?

PRDM1

Open it when you solve the case.

18/45

CASE 2

The signal

Which order starts the change into an antibody factory?

Clue from Tecnun's data: IRF4 is related to another gene in this case. In the game, that means it is in the chain.

Genes in this case

PRDM1 · IRF4 · AICDA · PAX5

2 links

1 — 2

11/45

CASE 5

No more variety

Once the cell is a factory, it stops varying its antibodies. Which order makes that happen?

Clue from Tecnun's data: AICDA is related to another gene in this case. In the game, that means it is in the chain.

Genes in this case

REL · RELA · PRDM1 · IRF4 · AICDA · PAX5

2 links

1 — 2

14/45

REWARD · CASE 2

?

IRF4

Open it when you solve the case.

17/45

CASE 1

The guardian

In an activated B lymphocyte, one gene switches another on so that antibodies can vary. Who switches on whom?

Clue from Tecnun's data: PAX5 is related to another gene in this case. In the game, that means it is in the chain.

Genes in this case

PRDM1 · AICDA · PAX5

2 links

1 — 2

10/45

CASE 4

A push from the family

Another gene, not IRF4, also helps start the change. Which one, and on whom?

Clue from Tecnun's data: RELA is related to another gene in this case. In the game, that means it is in the chain.

Genes in this case

REL · RELA · PRDM1 · IRF4 · AICDA · PAX5

2 links

1 — 2

13/45

REWARD · CASE 1

?

PAX5

Open it when you solve the case.

16/45

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The switcher

PRDM1 switches off PAX5

PRDM1 switches PAX5 off: the lymphocyte turns into an antibody factory.

The data say who is related to whom. Other studies say who gives the order.

There are more orders in the cell. This is the one for this case.

At the end of each game, read METHOD and LET'S TALK.

18/45

The signaller

It does different things depending on how much there is.

With a little IRF4, AICDA switches on.

IRF4 switches on PRDM1

When there is a lot of IRF4, it switches PRDM1 on.

This order comes from other studies, not from Tecnun's data.

There are more orders in the cell. This is the one for this case.

17/45

The guardian

It keeps the cell a B lymphocyte.

PAX5 switches on AICDA

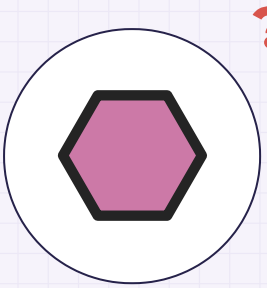
PAX5 switches AICDA on: the activated B lymphocyte can vary its antibodies.

This order comes from other studies, not from Tecnun's data.

There are more orders in the cell. This is the one for this case.

16/45

REWARD · CASE 4

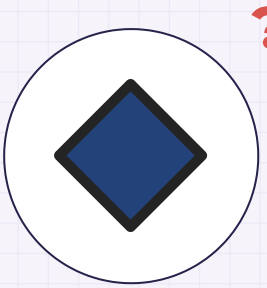


RELA

Open it when you solve the case.

19/45

REWARD · CASE 5



AICDA

Open it when you solve the case.

20/45

REWARD · FINAL CHALLENGE

6 possible chains

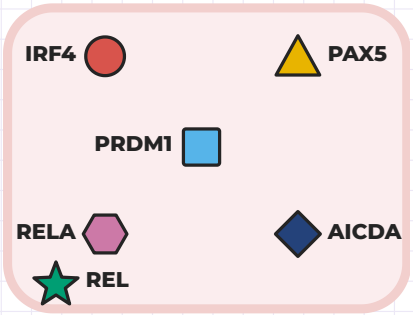
With Tecnun's data, all of them include IRF4, PRDM1 and PAX5. Without the data, there would be 120.

①	②	③
PRDM1	IRF4	PAX5
PRDM1	PAX5	IRF4
IRF4	PRDM1	PAX5
IRF4	PAX5	PRDM1
PAX5	PRDM1	IRF4
PAX5	IRF4	PRDM1

21/45

MAP

The cell map



Place each solved case around it. When the final challenge is done, turn this card over.

22/45

CHAINS · CASE 1

4 possible chains

With Tecnun's data, all of them include PAX5. Without the data, there would be 6.

①	②	①	②
PAX5	PRDM1	PRDM1	PAX5
PAX5	AICDA	AICDA	PAX5

23/45

CHAINS · CASE 2

6 possible chains

With Tecnun's data, all of them include IRF4. Without the data, there would be 12.

①	②	①	②
PRDM1	IRF4	IRF4	PRDM1
AICDA	IRF4	IRF4	AICDA
PAX5	IRF4	IRF4	PAX5

24/45

CHAINS · CASE 3

8 possible chains

With Tecnun's data, all of them include PRDM1. Without the data, there would be 20.

①	②	①	②
PRDM1	REL	REL	PRDM1
PRDM1	IRF4	IRF4	PRDM1
PRDM1	AICDA	AICDA	PRDM1
PRDM1	PAX5	PAX5	PRDM1

25/45

CHAINS · CASE 4

10 possible chains

With Tecnun's data, all of them include RELA. Without the data, there would be 30.

①	②	①	②
REL	RELA	RELA	REL
PRDM1	RELA	RELA	PRDM1
IRF4	RELA	RELA	IRF4
AICDA	RELA	RELA	AICDA
PAX5	RELA	RELA	PAX5

26/45

CHAINS · CASE 5

10 possible chains

With Tecnun's data, all of them include AICDA. Without the data, there would be 30.

①	②	①	②
AICDA	REL	REL	AICDA
AICDA	RELA	RELA	AICDA
AICDA	PRDM1	PRDM1	AICDA
AICDA	IRF4	IRF4	AICDA
AICDA	PAX5	PAX5	AICDA

27/45

FINAL CHALLENGE

The lymphocyte is now an antibody factory!



IRF4 switches on PRDM1 switches off PAX5

When there is a lot of IRF4, it switches PRDM1 on. And PRDM1 switches PAX5 off.

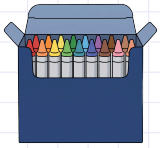
Tecnun measured that IRF4, PRDM1 and PAX5 work as a team. The arrows, who gives the order, come from other studies.

Turn the MAP over. Then read METHOD and LET'S TALK.

21/45

GENE · AICDA

The variety maker



It helps to vary antibodies.

PRDM1 switches off AICDA

PRDM1 switches AICDA off: the factory stops varying its antibodies.

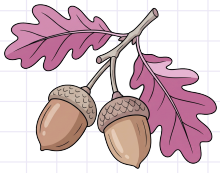
This order comes from other studies, not from Tecnun's data.

There are more orders in the cell. This is the one for this case.

20/45

GENE · RELA

The relative



REL and RELA are relatives, but they do different jobs.

RELA switches on PRDM1

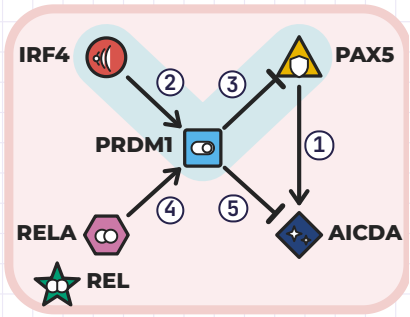
RELA helps switch PRDM1 on.

This order comes from other studies, not from Tecnun's data.

There are more orders in the cell. This is the one for this case.

19/45

MAP



→ switches on · ⊣ switches off

They work as a team: Tecnun measured it

There are more orders in the cell. These are the ones in this game.

22/45

EN · Quantum technologies · labur.eus/geneak · Zientzia Jolasak · Party game · Gene interactions

Put the board in the middle. Whoever is the cell sits on the side where the CASE goes.

Next to the board, in a column, the three REWARDS for this game, closed side up. Next to each one, its CASE.

Before the first case, read THE GENES aloud, both sides.

28/45

If you are the cell

Compare by number: link 1 with 1, link 2 with 2.

Same gene in the same place: ›.

A gene in the chain, but elsewhere: ↕.

A gene that isn't in the chain: nothing.

In the boxes, put the › first and then the ↕, without saying which ones. If there are none, say so aloud.

29/45

30/45

› in place ↕ elsewhere

31/45

32/45

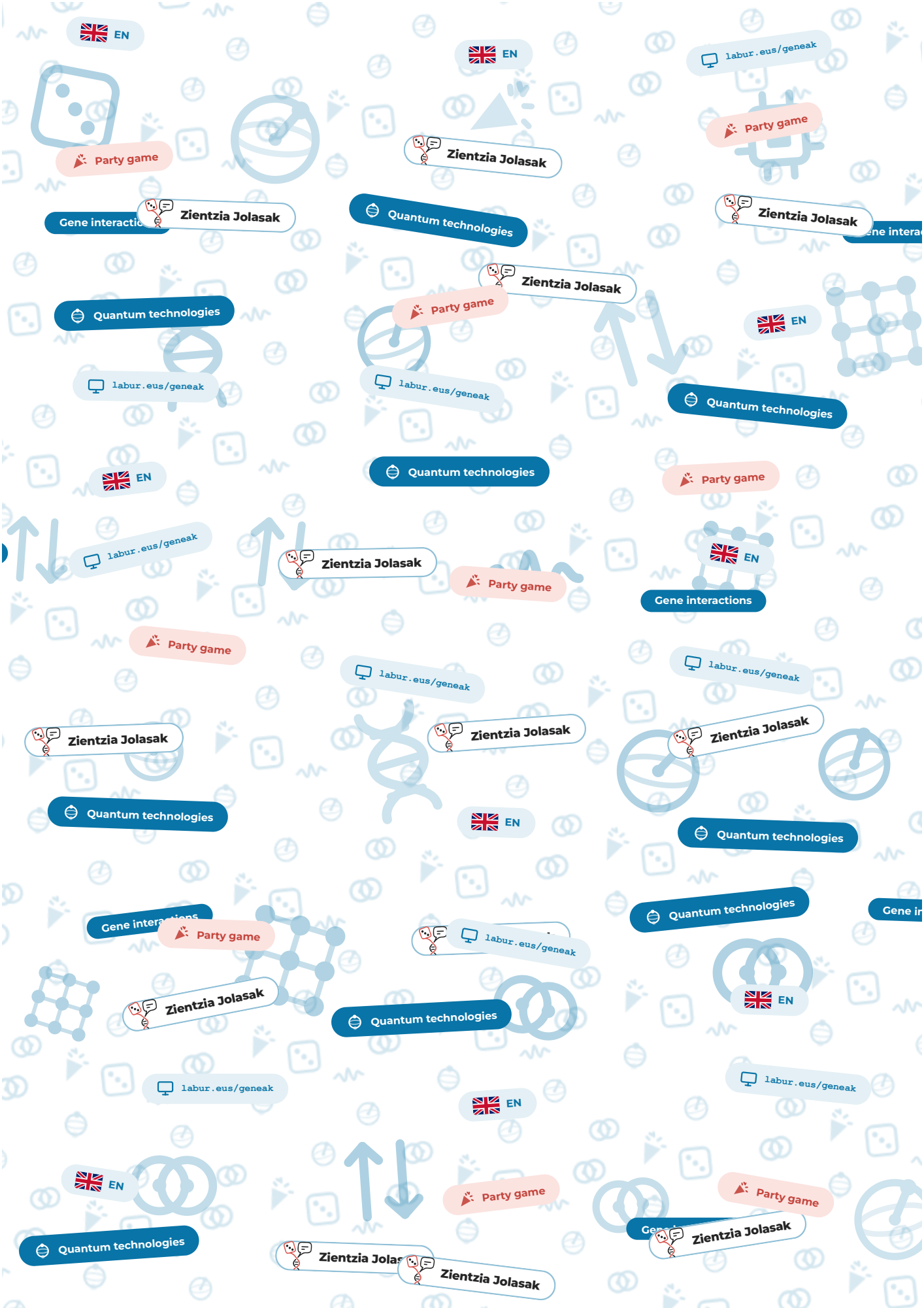
33/45

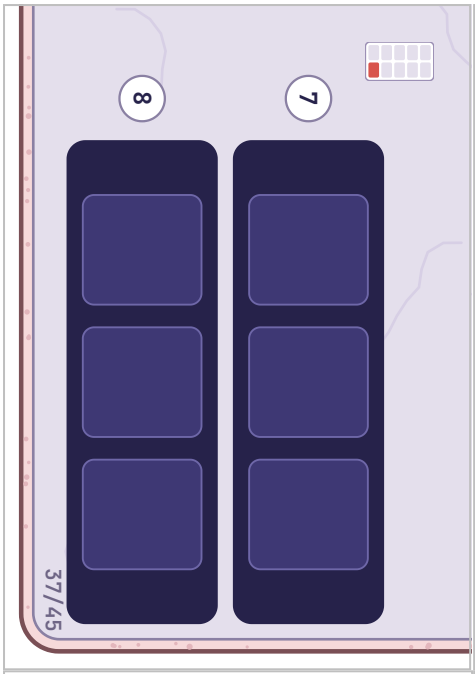
In a real cell, the genes are not lined up: the chain is just a drawing.

34/45

35/45

36/45


EN
Party game
Zientzia Jolasak
Quantum technologies
labur.eus/geneak
Gene interactions



IRF4	IRF4	IRF4
IRF4	IRF4	IRF4
PRDM1	PRDM1	PRDM1
PRDM1	PRDM1	PRDM1

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PAX5	PAX5	PAX5
PAX5	PAX5	PAX5
AICDA	AICDA	AICDA
AICDA	AICDA	AICDA

39/45

REL	REL	REL
REL	REL	REL
RELA	RELA	RELA
RELA	RELA	RELA

40/45

IRF4	PRDM1	PAX5
IRF4	PRDM1	PAX5
IRF4	PRDM1	PAX5
IRF4	PRDM1	PAX5

41/45

AICDA	REL	RELA
AICDA	REL	RELA
AICDA	REL	RELA
AICDA	REL	RELA

42/45

✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓

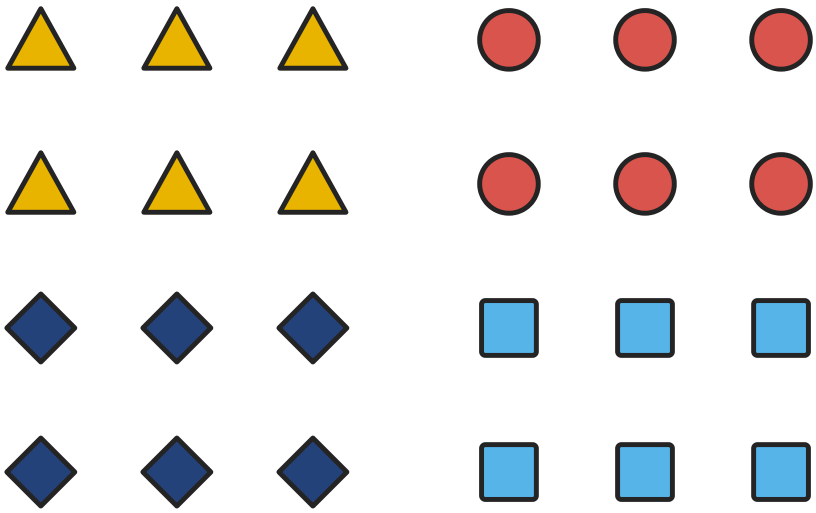
43/45

✓	✓	✓	✓
↔	↔	↔	↔
↔	↔	↔	↔
↔	↔	↔	↔

44/45

↔	↔	↔	↔
↔	↔	↔	↔
↔	↔	↔	↔
↔	↔	↔	↔
↔	↔	↔	↔

45/45



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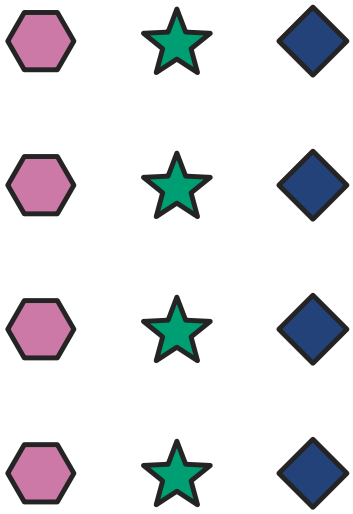
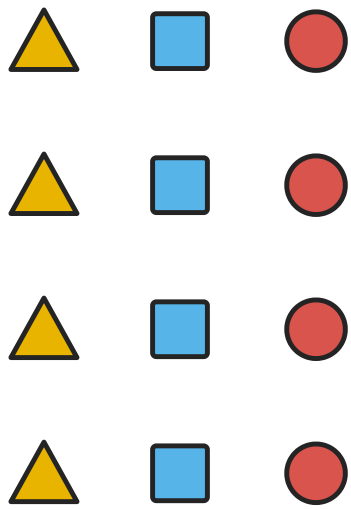
38/45

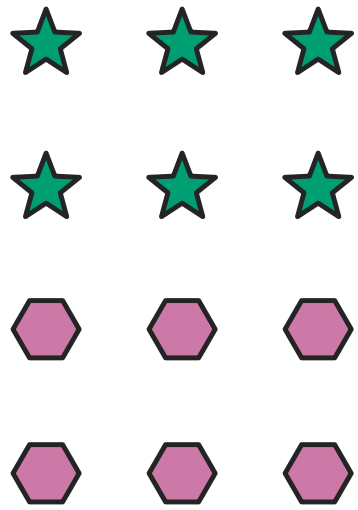




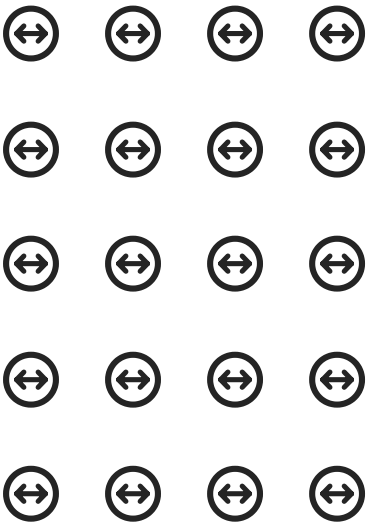
42/45



41/45



40/45



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