PHYSICAL DESIGN WORKSHOP

BUILD, TEST AND DOCUMENT THE PIG EXPERIMENT

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WORKSHOP ROUTE

Time	Activity
13:25-13:40	Build the facility
13:55-14:15	Test a diet allocation
14:15-14:35	Randomise within rooms
14:35-14:55	Build the factorial design
15:10-15:25	Group check
15:25-15:45	Stress test
15:45-16:00	Design table and exit

KIT CHECK

Each group has:

- one grey 32 × 32 baseplate and four azure 16 × 16 room plates
- sixteen yellow 4 × 4 pen plates and 96 pink 1 × 1 pig bricks
- sixteen green and sixteen red 1 × 4 tiles
- 96 transparent 1 × 1 plates in each of five colours

The main design uses eight green tiles, eight red tiles and eight transparent blue plates.

> Reuse the same facility at every stage.

GROUP ROLES

- **Builder:** moves pieces after the group agrees
- **Recorder:** records the realised allocation
- **Design lead:** explains the scientific reasoning
- **Skeptic:** checks confounding, replication and randomisation

Groups of three combine recorder and design lead.

STUDY BRIEF

Sixteen pig pens occupy four rooms. Every room contains four pens, and every pen contains six pigs.

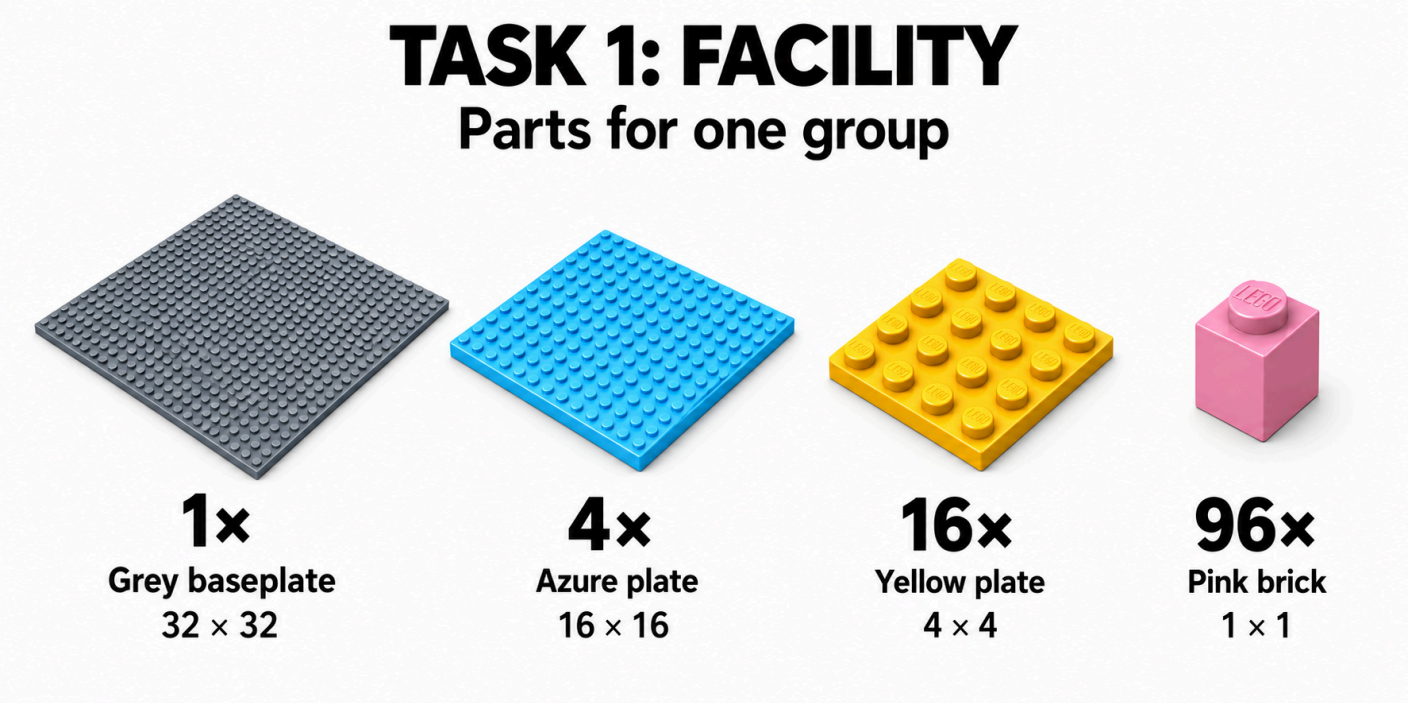
Researchers will study diet, housing and average daily gain. Feed and enrichment apply to whole pens. Every pig is weighed.

What part of the facility can receive a different treatment independently?

PHYSICAL STRUCTURE

BUILD BEFORE ALLOCATING

TASK 1 PARTS



Collect these parts from your group's kit. Keep treatment markers aside. You will also need paper labels and a pen.

FACILITY BUILD

Build:

- four labelled rooms
- four labelled pens in every room
- six pigs in every pen

Do not add treatment markers.

Piece	Represents
Yellow 4 × 4 plate	One pen
Six pink 1 × 1 bricks	Six pigs
Green/red 1 × 4 tile	Diet for the whole pen

STRUCTURE CHECK

Agree within the group:

1. What is the experimental unit?
2. What is the observational unit?
3. How many independent units are available?
4. How many animals will be observed?
5. What grouping could form a block?

BREAK

Leave the physical structure intact.

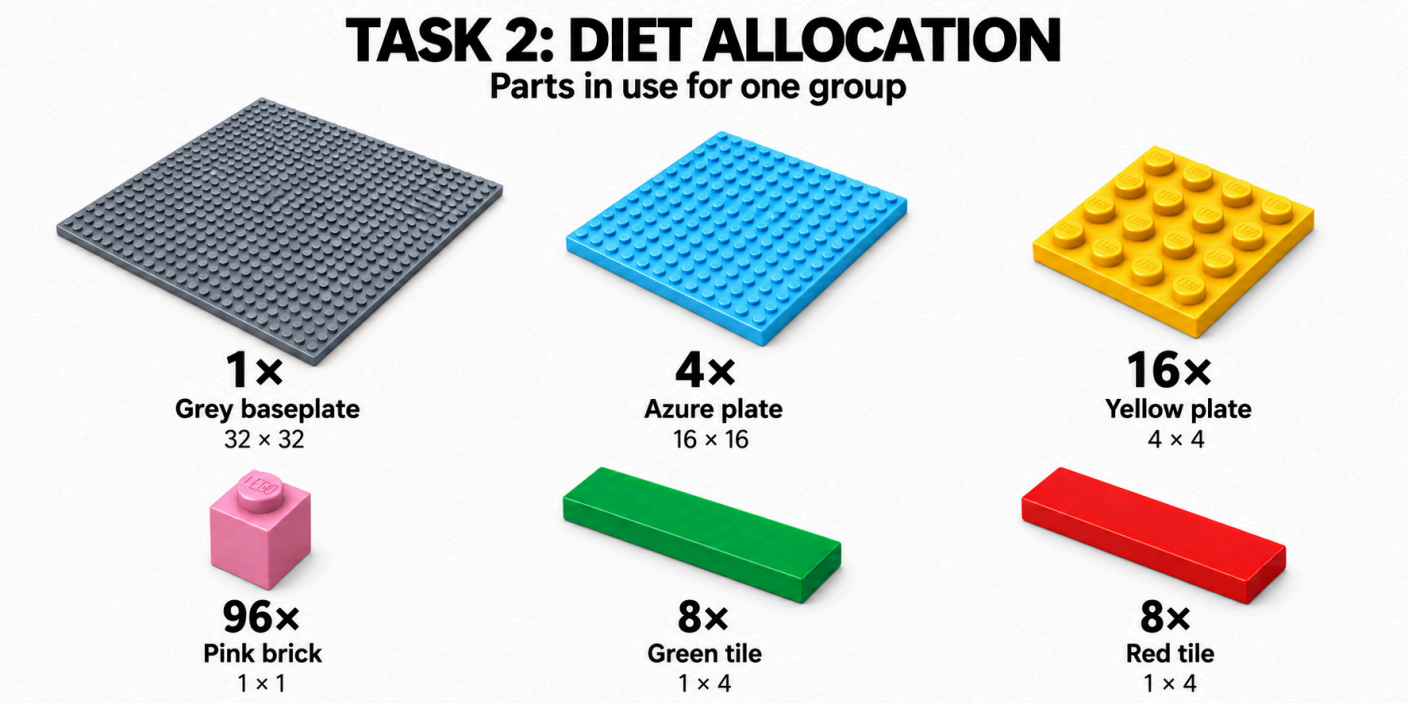
After the break, collect:

- 8 green diet markers
- 8 red diet markers

DIET ALLOCATION

BUILD, DIAGNOSE, REBUILD

TASK 2 PARTS



Keep the built facility and pigs. Add eight green and eight red tiles. These counts include reused pieces.

FIRST ALLOCATION

Use:

- 8 green markers for standard diet
- 8 red markers for high-fibre diet

Arrange the diets in any way your group initially considers sensible.

Record or photograph the layout before changing it.

ALLOCATION AUDIT

For your first layout:

- Are the diet totals equal?
- Do both diets occur in every room?
- Did chance determine pen positions?
- Could room differences appear as a diet effect?
- Can the diets be compared within every room?

FOUR LAYOUTS

Example	Pen positions 1–4	Procedure
A	G, G, G, G	Same diet throughout
B	G, R, G, R	Deliberately alternating
C	R, G, G, R	Unseen draw, recorded
D	G, R, R, G	Procedure unknown

G = green, standard diet. R = red, high-fibre diet.

> Which design features can you verify from appearance alone?

ROOM DIFFERENCES



Could any of these differences be mistaken for a diet effect in your first layout?

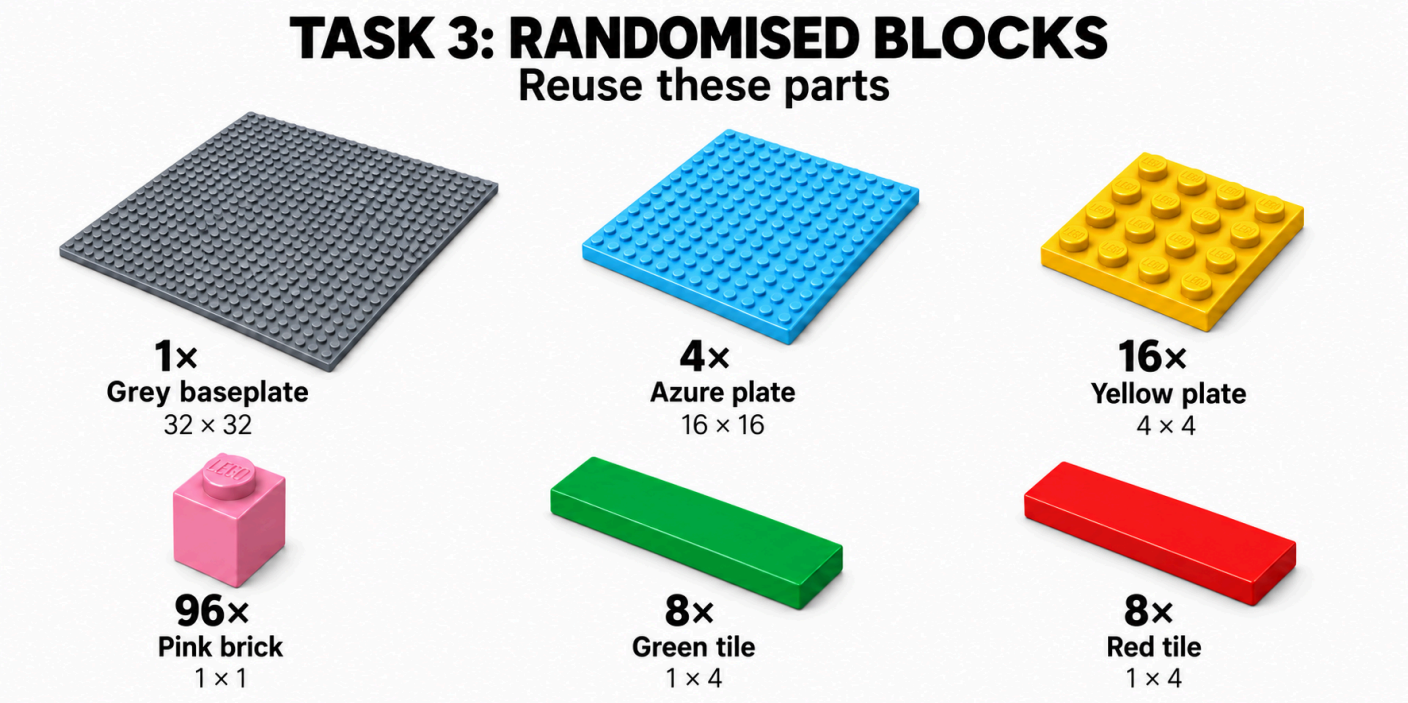
BLOCKED RULE

Rebuild the diet allocation:

- every room contains two green and two red markers
- mix the four markers unseen
- draw separately for each room
- record every realised pen assignment

> The counts are fixed. Chance chooses the positions.

TASK 3 PARTS



Reuse the same parts. No additional LEGO is needed. Have a cup or bag ready for the unseen draw.

PHYSICAL RANDOMISATION

1. Label the four pen positions.
2. Mix two green and two red tiles unseen.
3. Draw one tile for each position.
4. Record the order.
5. Repeat separately for every room.

Repeat the draw independently in Rooms 1, 2, 3 and 4.

ALLOCATION RECORD

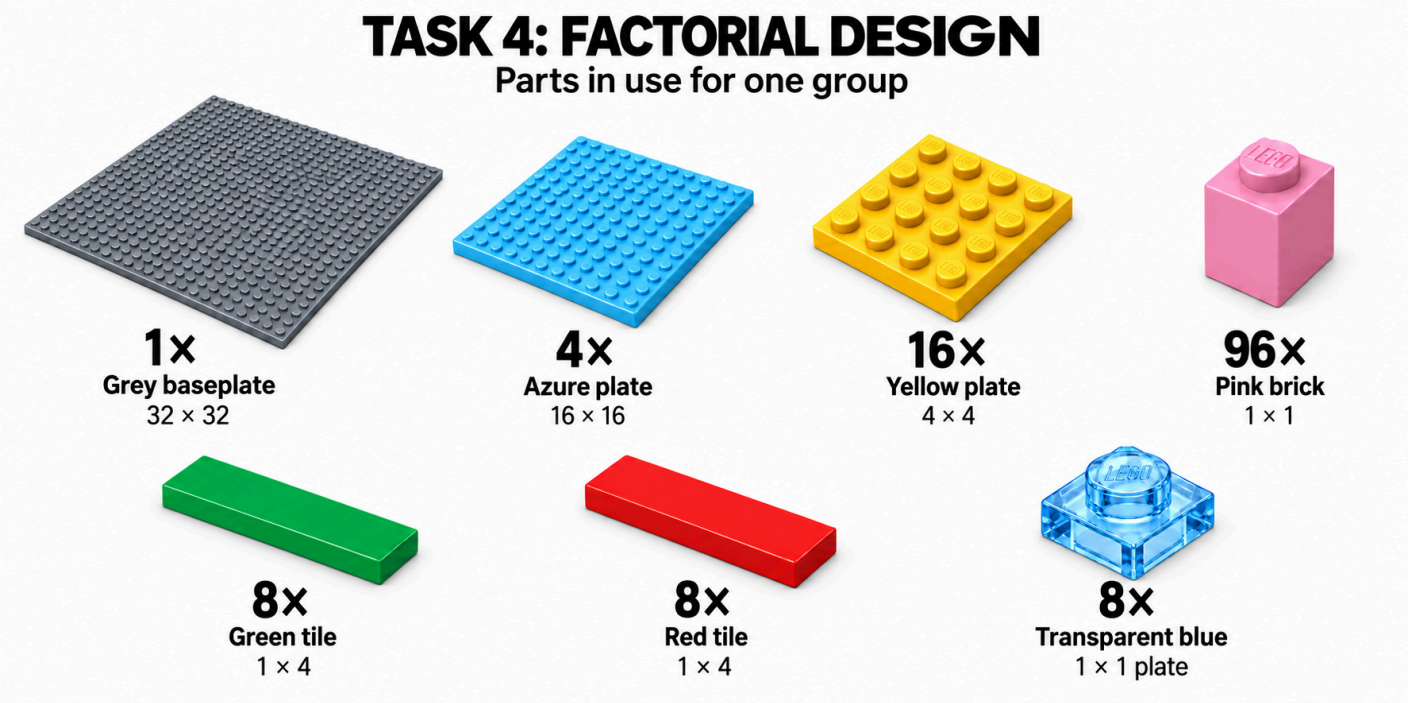
Room	Pen positions	Required count
1	____ ____ ____ ____	2 green, 2 red
2	____ ____ ____ ____	2 green, 2 red
3	____ ____ ____ ____	2 green, 2 red
4	____ ____ ____ ____	2 green, 2 red

> Why is “we randomised” insufficient documentation?

FACTORIAL REBUILD

TWO FACTORS IN THE SAME 16 PENS

TASK 4 PARTS



Keep the facility, pigs and diet tiles. Add eight transparent blue plates and collect the four printed combination cards.

FOUR COMBINATIONS

Combination	Diet tile	Transparent blue plate
SS	Green	Absent
HS	Red	Absent
SE	Green	Present
HE	Red	Present

Code	Diet	Housing
SS	standard	standard
HS	high-fibre	standard
SE	standard	enriched
HE	high-fibre	enriched

DESIGN CONSTRAINTS

The final design must have:

- all four combinations in every room
- one pen per combination within each room
- a separate card shuffle for every room
- a complete record of the realised positions
- the same 16 pens and 96 pigs

RANDOMISE ONE ROOM

For each room:

1. Shuffle SS, HS, SE and HE unseen.
2. Name a fixed order for the four pen positions.
3. Draw one card for each position.
4. Place the matching green or red marker.
5. Add blue only for SE and HE.
6. Record the result before reusing the cards.

MODEL AUDIT

Check the completed model:

- four pens for SS, HS, SE and HE overall
- one SS, HS, SE and HE pen in every room
- eight green and eight red markers
- eight pens with blue and eight without
- four independent pen replicates per combination

BREAK

Leave the completed factorial model and allocation record intact.

After the break:

- finish your model and allocation record
- request a brief instructor check when ready
- keep the original model intact for the stress test

DESIGN AUDIT

TEST THE DESIGN WITHOUT ADDING PIECES

GROUP CHECK

Check your own model and allocation record together:

1. Does every room contain all four combinations?
2. Did you record the chance procedure?
3. Is either factor confounded with room?
4. How many independent pen replicates exist per combination?
5. How many pigs are observed per combination?

Ask the instructor to check your reasoning before the stress test.

CROSSED OR CONFOUNDED?

Design A	Design B
Standard diet, standard housing	Standard diet, standard housing
High-fibre diet, standard housing	Standard diet, standard housing
Standard diet, enriched housing	High-fibre diet, enriched housing
High-fibre diet, enriched housing	High-fibre diet, enriched housing

> Which design contains all four treatment combinations? What comparison is missing from the other design?

STRESS TEST

After the instructor checks your model, open your group's stress-test card.

- change only what the card requests
- count experimental units again
- count observations again
- check treatment replication and balance
- record missingness or protocol changes

> Do not add pieces that are not in your kit.

REPORT BACK

Give the instructor a 90-second report:

- describe the event
- state what changed
- state what did not change
- recommend the next action
- name what must be documented

DESIGN RECORD

TRANSLATE THE MODEL INTO ROWS

ONE ROW PER PEN

room	pen	diet	housing	combination	n_pigs
1	1	_____	_____	____	6
1	2	_____	_____	____	6
1	3	_____	_____	____	6
1	4	_____	_____	____	6

Continue for all 16 pens using your realised order.

TABLE CHECKS

Your design table should contain:

- 16 rows and 16 distinct pen identifiers
- four rows for every treatment combination
- one row for every combination within each room
- diet and housing repeated for pigs sharing a pen in an observation table

> Why can an observation table contain 96 rows without providing 96 treatment replicates?

BUILD CHALLENGES

After the stress test, report-back and design table:

- save the original allocation and stress-test record
- draw one build-challenge card
- construct the specified design with the same kit
- diagnose its design properties
- repair it, or explain why the constraint prevents a complete design

> A convincing layout still needs a defensible allocation procedure.

Parts inventories: 1, 2, 3, 4, 5, 6, 7, 8, 9.

CHALLENGE REPORT

For every additional design, report:

1. What is balanced?
2. What comparison occurs within a block?
3. What was randomised?
4. What is confounded or otherwise limited?
5. How many independent pen replicates remain?
6. What repair or conclusion is justified?

Rebuild only after the instructor checks your design table.

EXTRA FACTORIAL DESIGNS

The final three cards change the study setting:

Card	Factors	Hypothetical facility
7	Diet, housing and feeding	Two rooms of eight pens
8	Diet and three housing levels	Two rooms of six pens
9	Diet, housing, feeding and lighting	Sixteen pens in one common environment

Use the legend on each card. A colour can have a different meaning in a different study.

FOUR-FACTOR CHALLENGE

Factor	First level	Second level
Diet	Green tile: standard	Red tile: high-fibre
Housing	No blue plate: standard	Blue plate: enriched
Feeding	No orange plate: once daily	Orange plate: twice daily
Lighting	No yellow plate: standard	Yellow plate: extended

- Set the azure room plates aside for this new common-environment scenario.
- Use all 16 pens and include every treatment combination.
- Randomly allocate combinations to pens and record the allocation.

REPLICATION CHECK

For the four-factor build:

1. How many pens receive each complete treatment combination?
2. How many pens receive each individual factor level?
3. Do the six pigs replicate their pen's treatment allocation?
4. What changes if one pen is lost?
5. How could you obtain two pens per combination using the same kit?

WORKSHOP SYNTHESIS

For the original two-factor experiment:

- Pens received the treatment combinations.
- Rooms formed complete blocks.
- Chance selected positions within rooms.
- Two factors produced four combinations.
- Four pens independently replicated each combination.
- Complications affected units, observations or measurements differently.

EXIT QUESTIONS

Answer individually about the original two-factor experiment:

1. What is the experimental unit, and why?
2. What is the block?
3. How many pen replicates are there per combination?
4. What scientific question does the interaction address?
5. Would weekly weighing increase treatment replication?

CHALLENGE 1 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

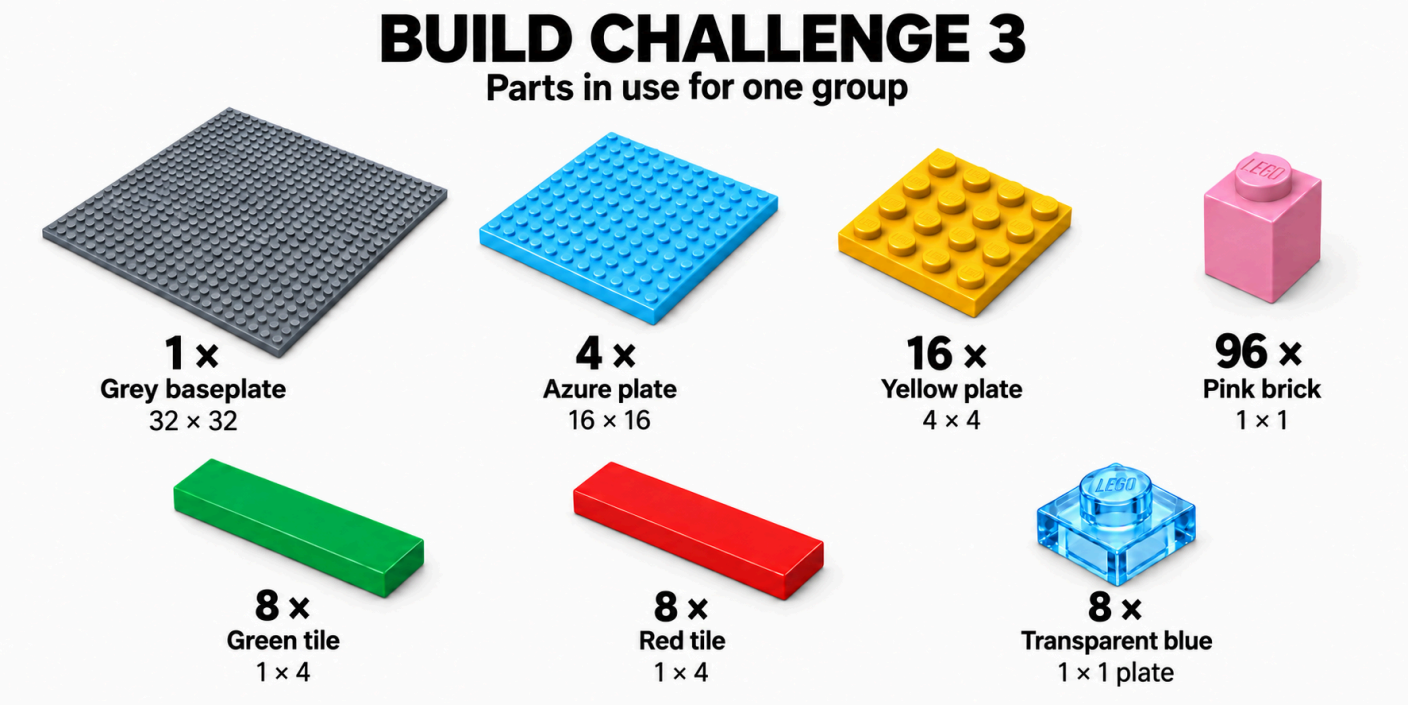
CHALLENGE 2 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

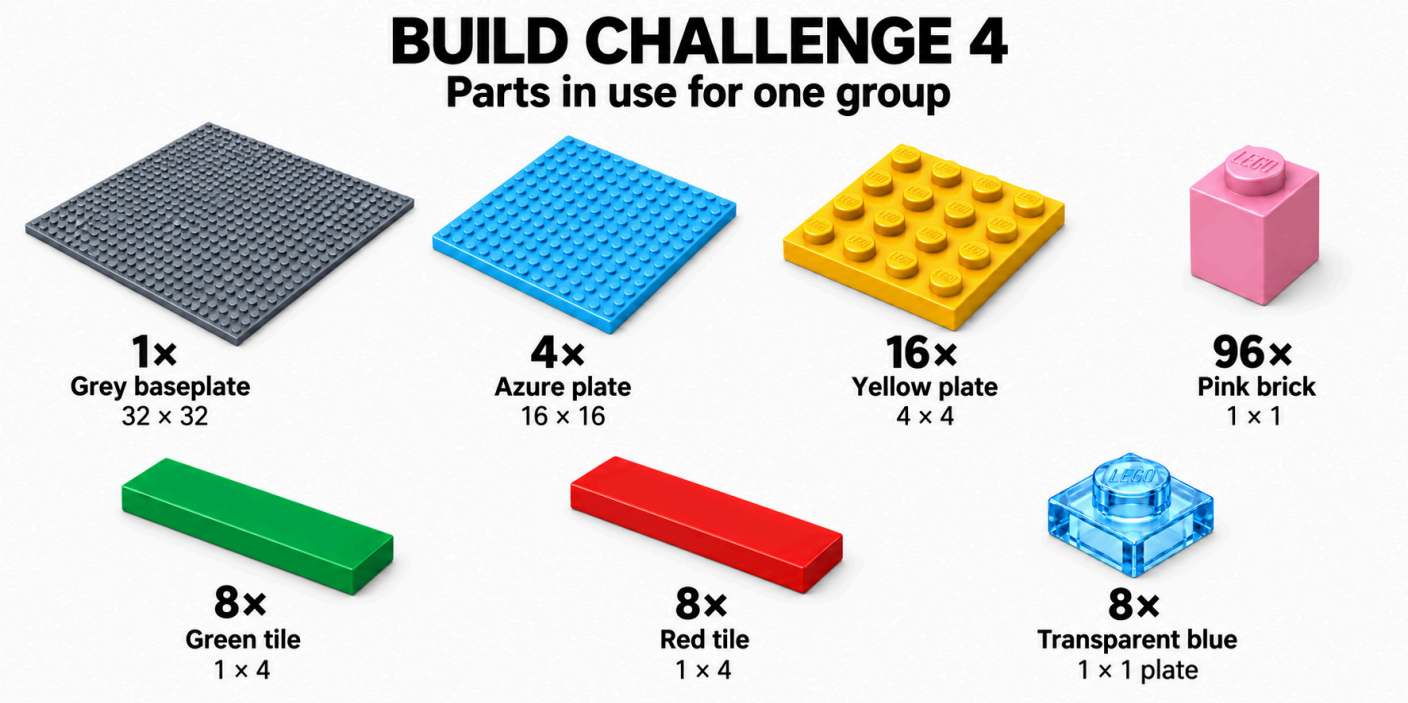
CHALLENGE 3 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

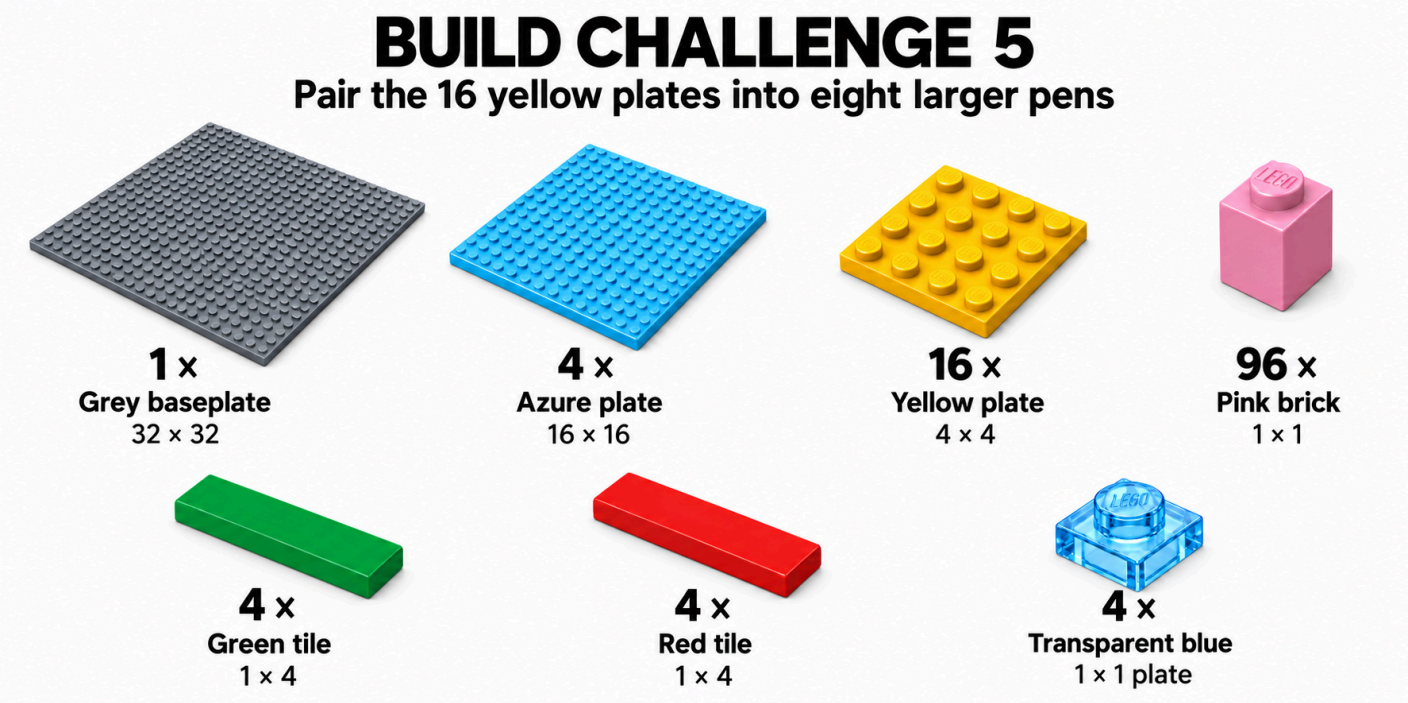
CHALLENGE 4 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

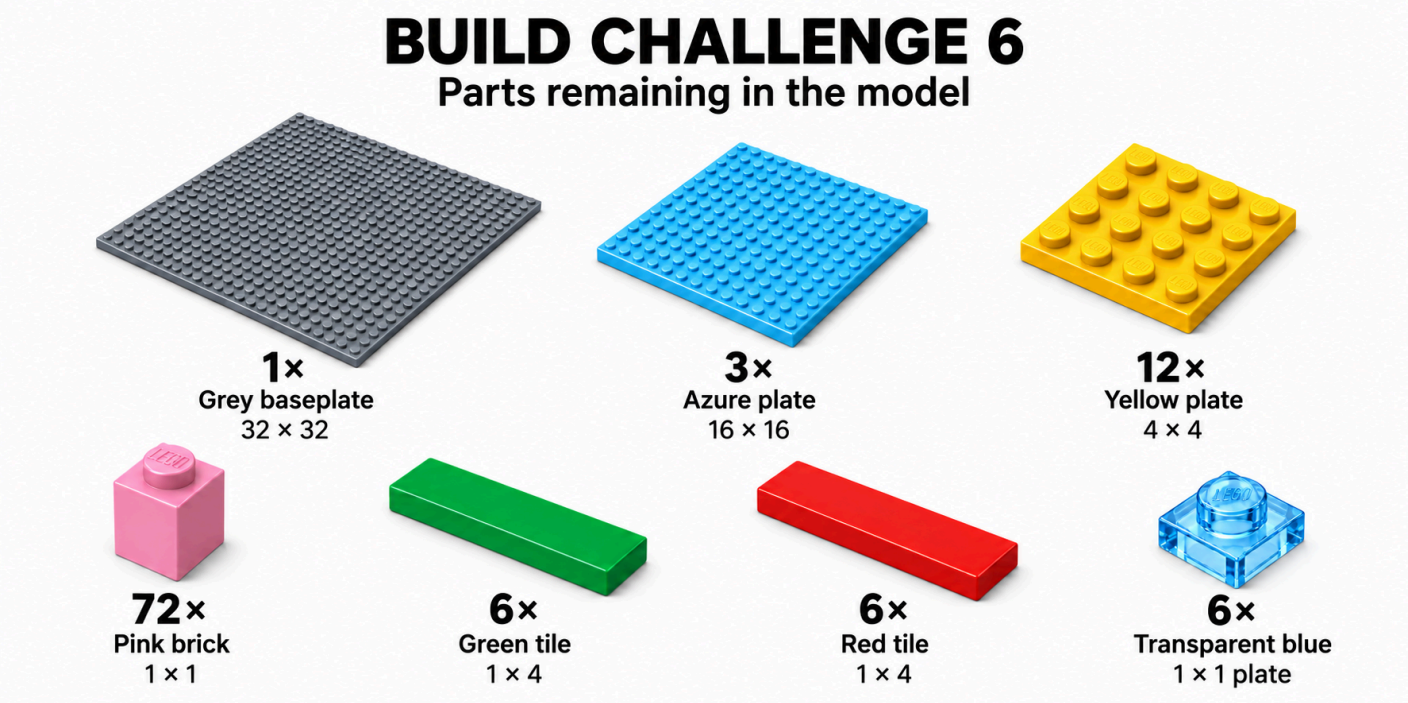
CHALLENGE 5 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

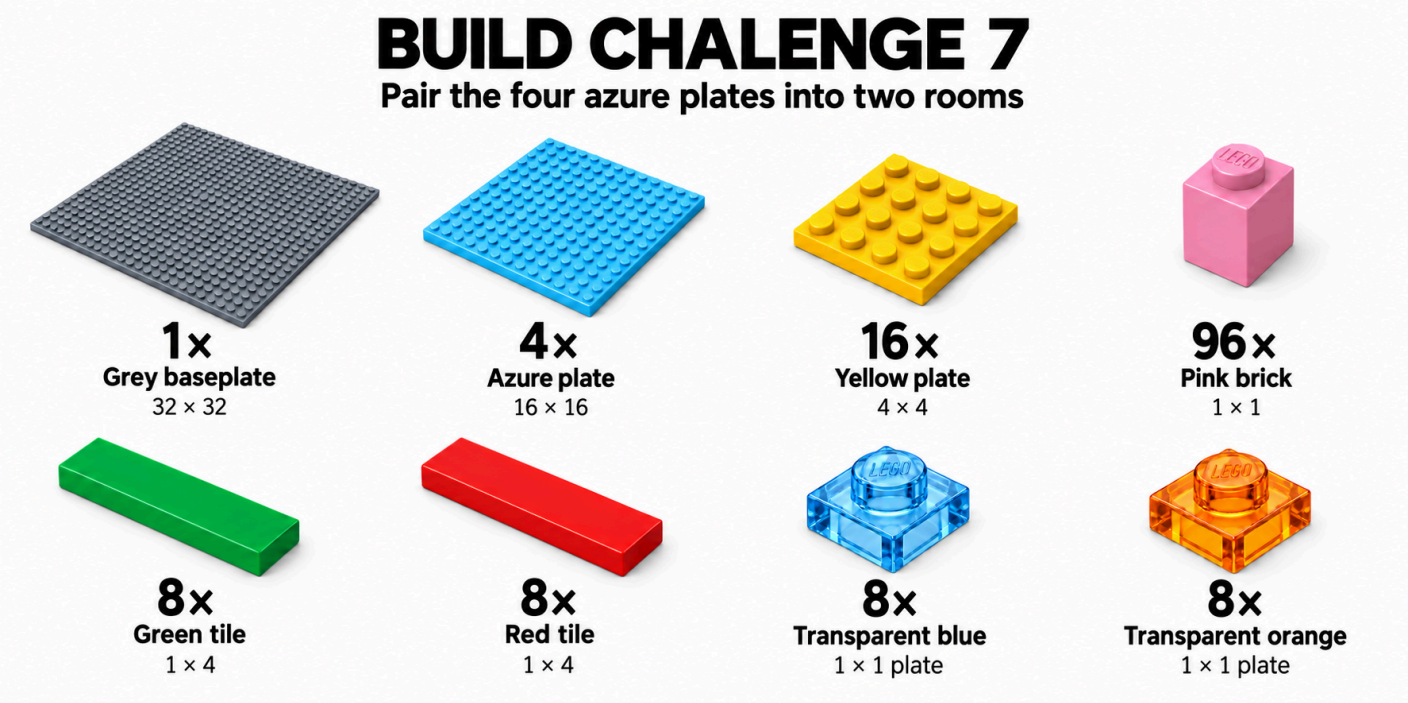
CHALLENGE 6 KIT



The image shows the remaining model. Set the unused room and its contents aside.

Back to challenges

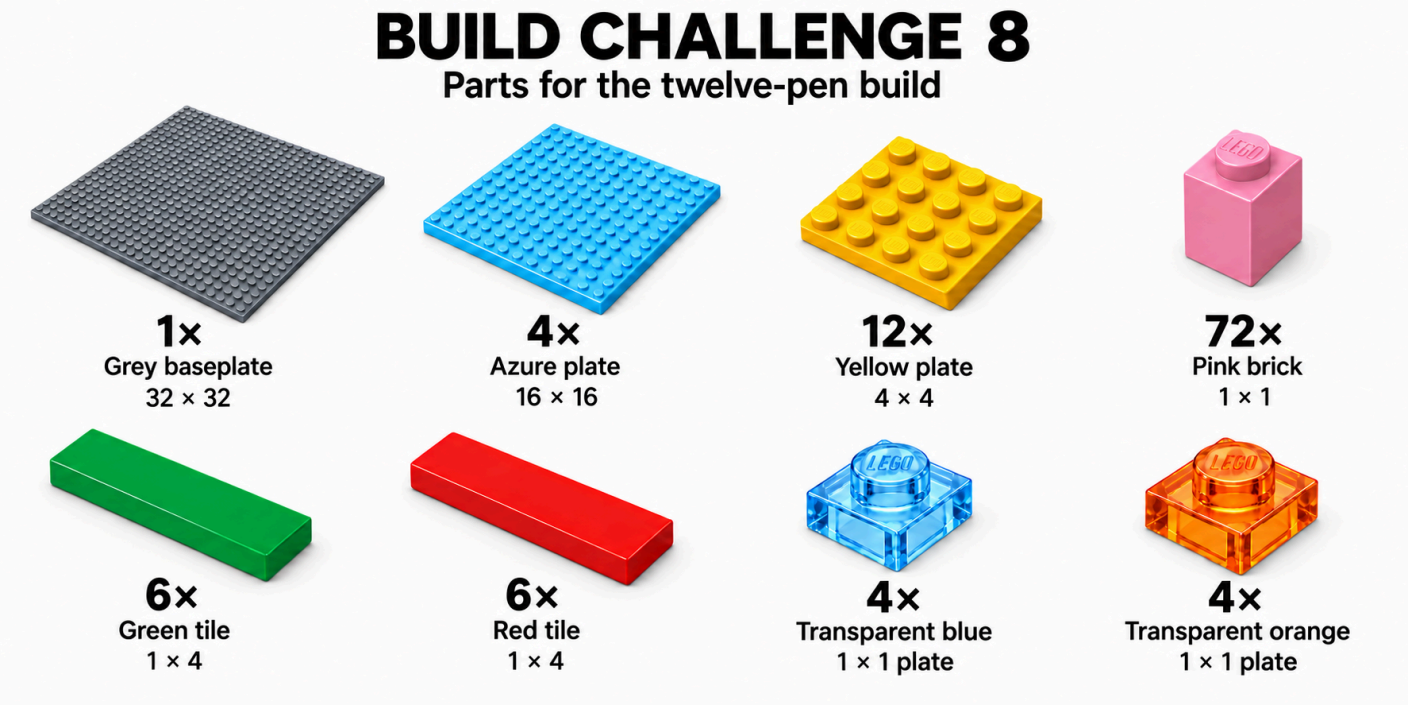
CHALLENGE 7 KIT



Reuse your group's pieces. Put unlisted markers aside and follow the challenge sheet.

Back to challenges

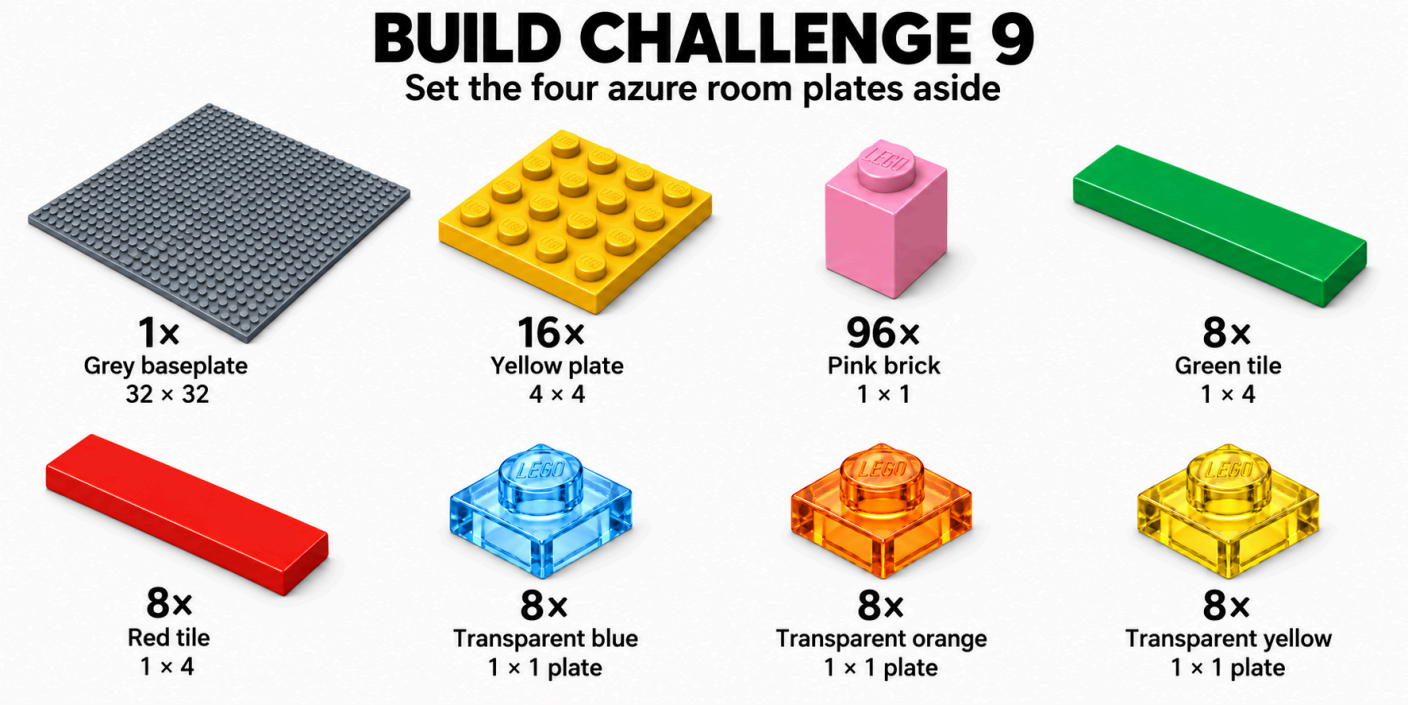
CHALLENGE 8 KIT



Set four yellow plates and 24 pink bricks aside. The image shows the initial 12-pen build.

Back to challenges

CHALLENGE 9 KIT



Set all four azure plates aside. Use paper slips for random allocation.

Back to challenges

SOURCES

Ruxton, Graeme D., and Nick Colegrave. 2016. *Experimental Design for the Life Sciences*. 4th ed. Oxford: Oxford University Press.

- Chapter 7: randomisation
- Chapter 8: factorial designs
- Chapter 9: blocking and covariates

Publisher page