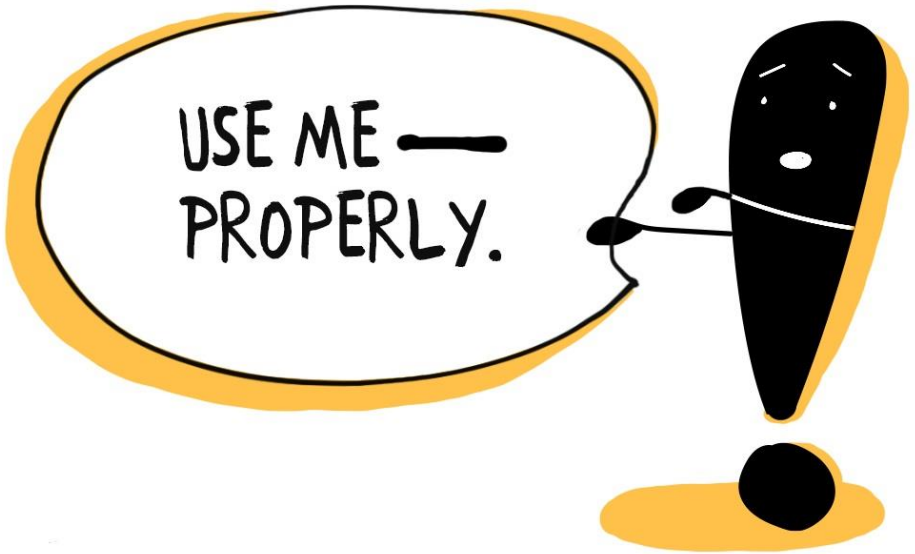
Factorial Notation



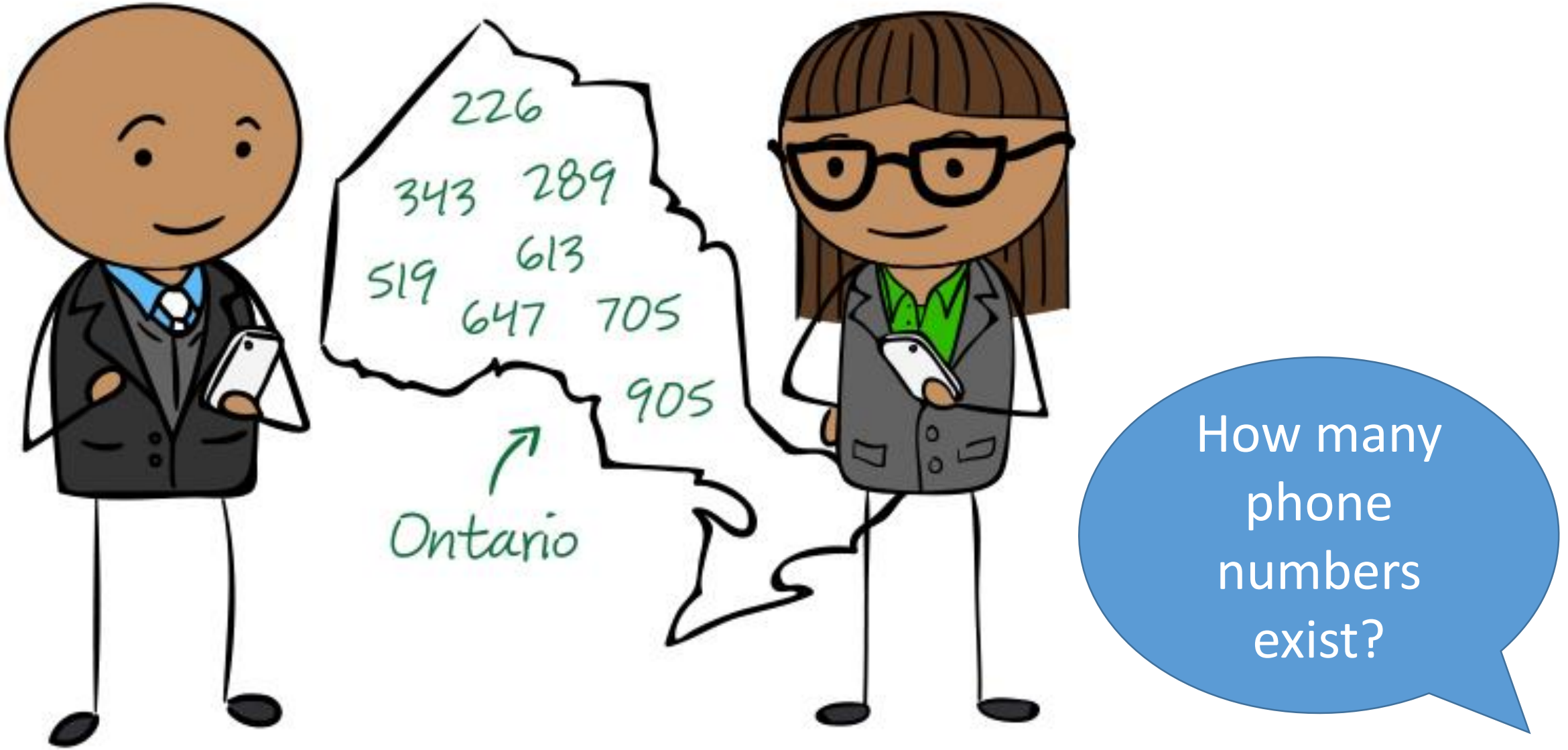
How can we find out how many things there are without counting them?

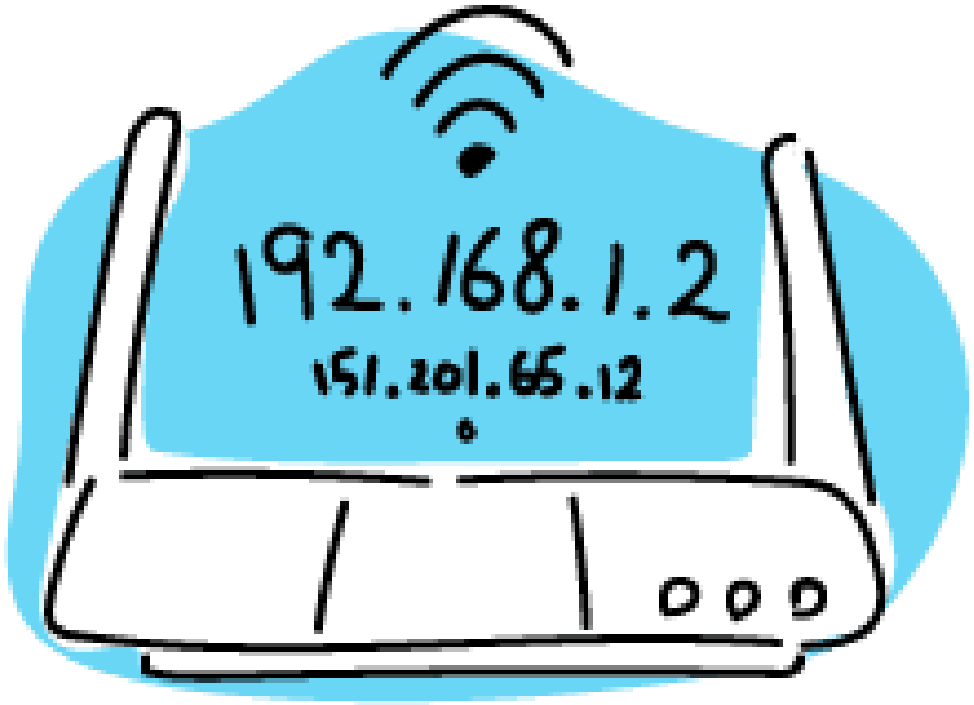
When the licence plates have 5 numerical digits how many were there?

What about when it went up to 6 digits?

What about when we added letters?

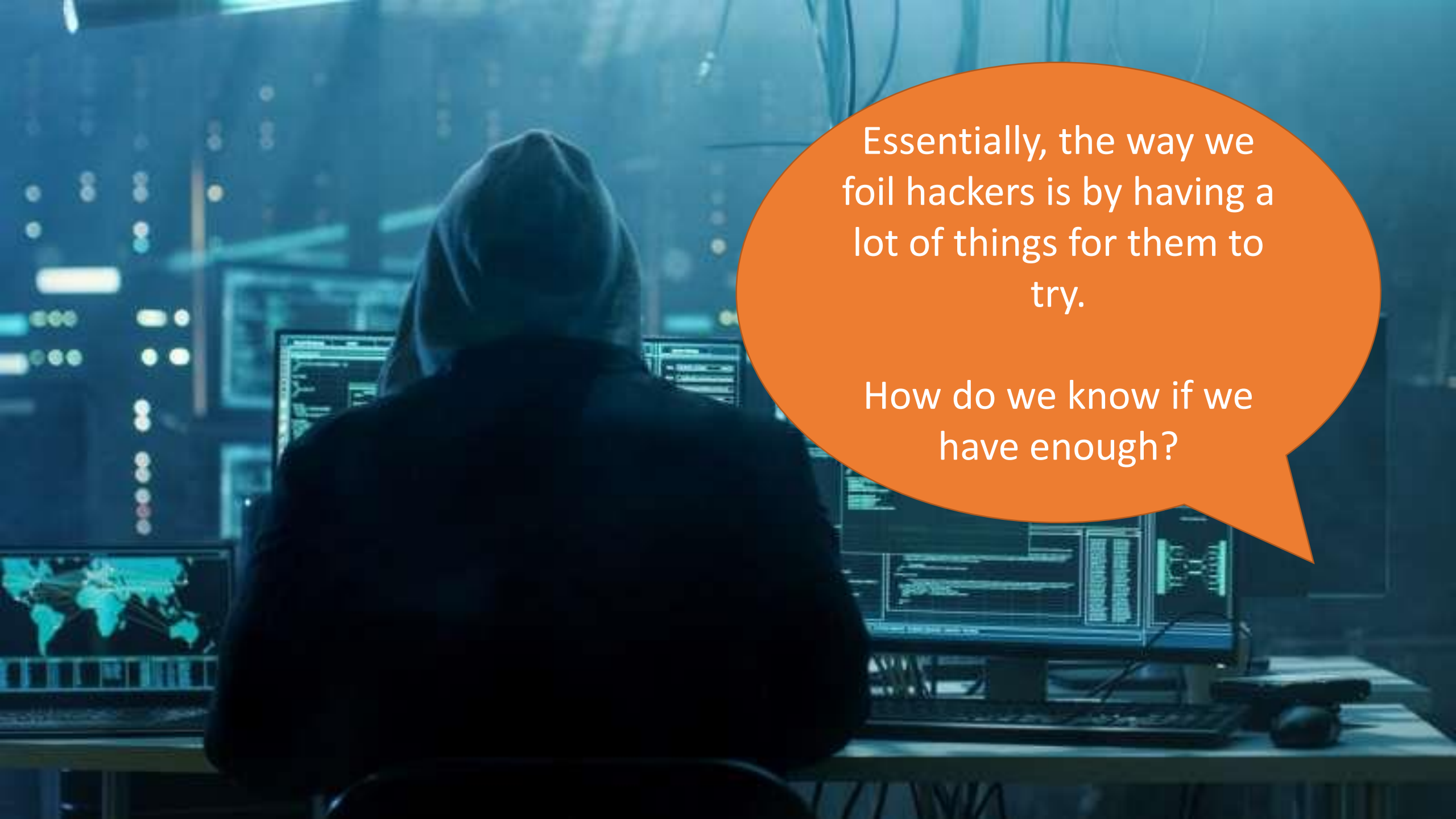
Now, how many?


226
343
289
613
519
647
705
905
Ontario
How many phone numbers exist?



My IP Address
63.255.173.183

How many internet addresses exist?


Essentially, the way we foil hackers is by having a lot of things for them to try.
How do we know if we have enough?

Suppose that we have 1 thing. How many ways can it be arranged?

Suppose that we have 1 thing. How many ways can it be arranged?

A

Suppose that we have 2 things. How many ways can they be arranged?

Suppose that we have 2 things. How many ways can they be arranged?

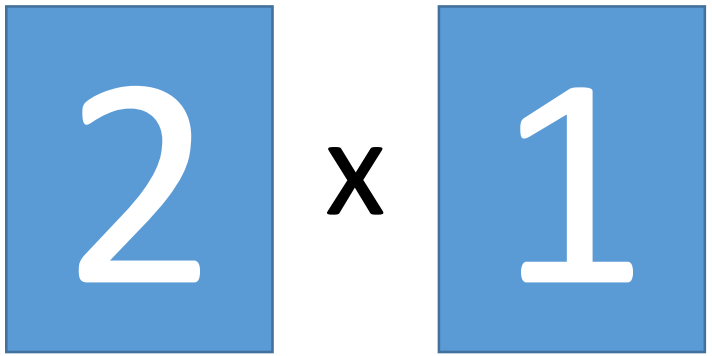
AB

BA

Suppose that we have 2 things. How many ways can they be arranged?

AB

BA



Suppose that we have 3 things. How many ways can they be arranged?

Suppose that we have 3 things. How many ways can they be arranged?

ABC ACB

BAC BCA

CBA CAB

Suppose that we have 3 things. How many ways can they be arranged?

ABC ACB

BAC BCA

CBA CAB

Suppose that we have 4 things. How many ways can they be arranged?

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ABCD ABDC ACBD ACDB ADCB ADBC

BACD BADC BCAD BCDA BDCA BDAC

CABD CBAD CADB CABD CDAB CDBA

DABC DBAC DBAC DBCA DCAB DCBA

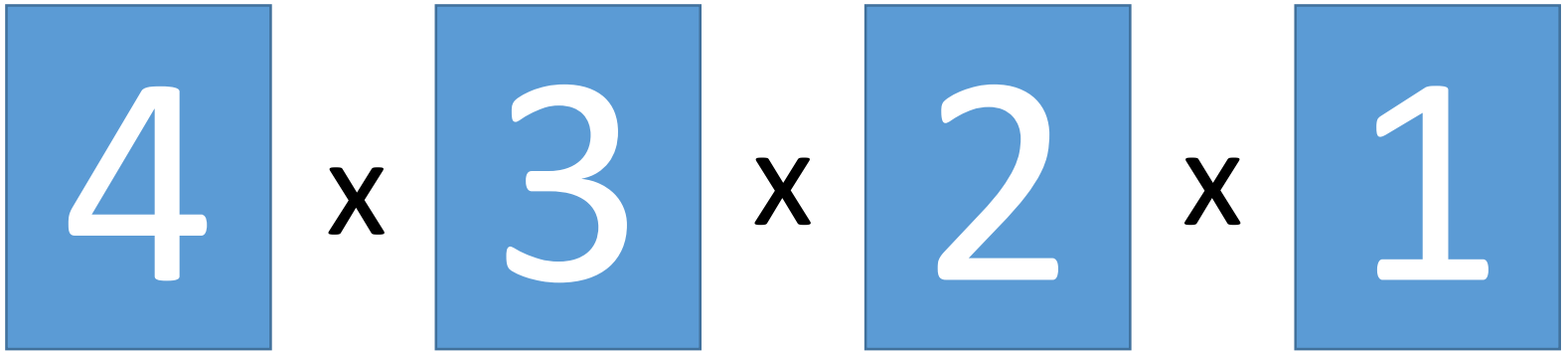
Suppose that we have 4 things. How many ways can they be arranged?

ABCD ABDC ACBD ACDB ADCB ADBC

BACD BADC BCAD BCDA BDCA BDAC

CABD CBAD CADB CABD CDAB CDBA

DABC DBAC DBAC DBCA DCAB DCBA



A factorial is the product of an integer and all the integers below it.

$1! = 1 = 1$

$2! = 2 = 1 \times 2$

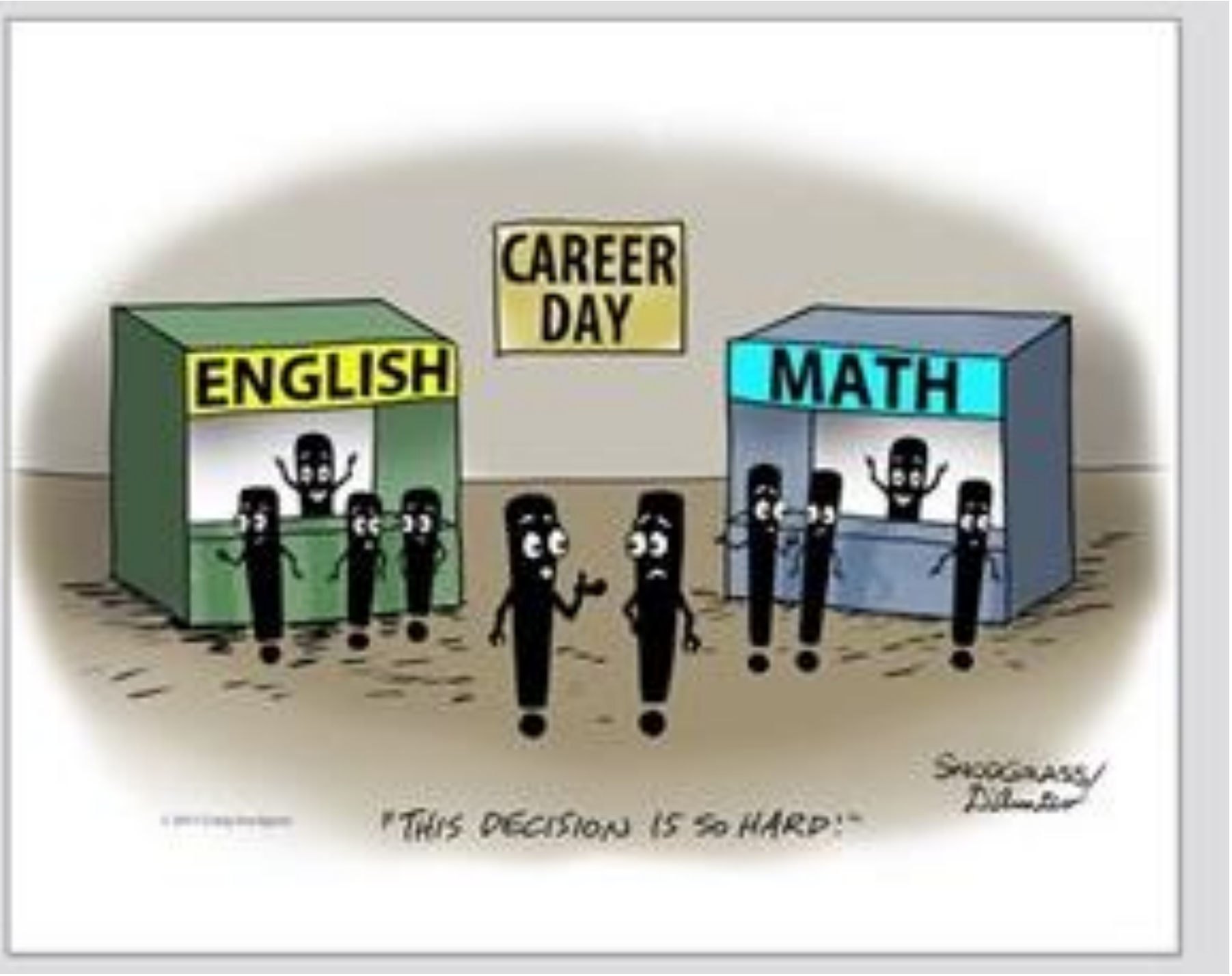
$3! = 6 = 1 \times 2 \times 3$

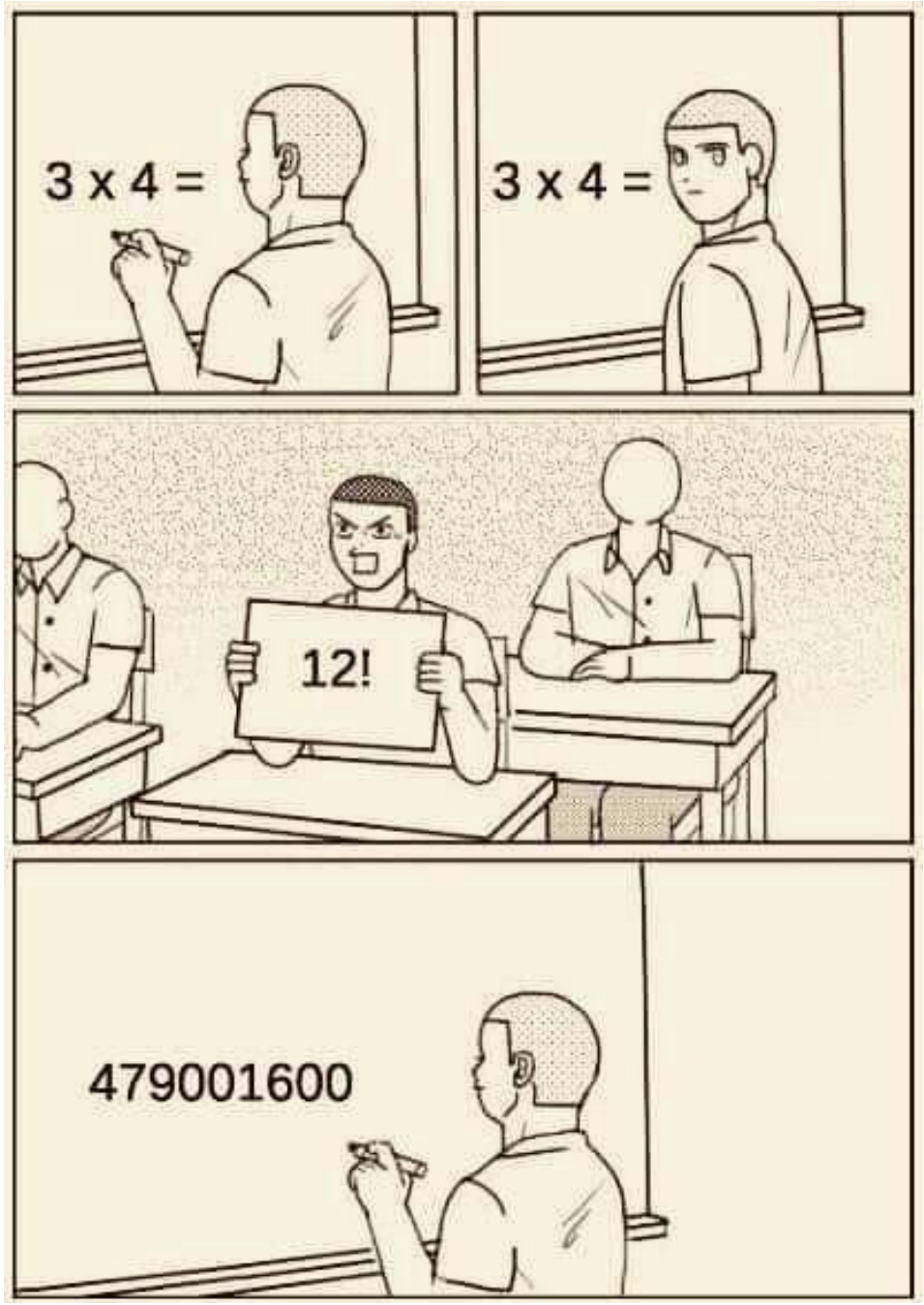
$4! = 24 = 1 \times 2 \times 3 \times 4$

$5! = 120 = 1 \times 2 \times 3 \times 4 \times 5$

	A	B	C	D
1	0	!	=	1
2	1	!	=	1
3	2	!	=	2
4	3	!	=	6
5	4	!	=	24
6	5	!	=	120
7	6	!	=	720
8	7	!	=	5040
9	8	!	=	40320
10	9	!	=	362880
11	10	!	=	3628800
12	11	!	=	39916800
13	12	!	=	479001600

- Factorials grow very quickly.
- This is why counting things by hand can be difficult.


CAREER DAY
ENGLISH
MATH
"THIS DECISION IS SO HARD!"



Get it?

	A	B	C	D
1	0	!	=	1
2	1	!	=	1
3	2	!	=	2
4	3	!	=	6
5	4	!	=	24
6	5	!	=	120
7	6	!	=	720
8	7	!	=	5040
9	8	!	=	40320
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How else can you express 5!

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$5! = 1 \times 2 \times 3 \times 4 \times 5$

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Write using factorials

$$3 \times 4 \times 5 \times 6 =$$

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$$3 \times 4 \times 5 \times 6 = \frac{1 \times 2 \times 3 \times 4 \times 5 \times 6}{1 \times 2 \times 3}$$

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$$3 \times 4 \times 5 \times 6 = \frac{1 \times 2 \times 3 \times 4 \times 5 \times 6}{1 \times 2 \times 3}$$

$$= \frac{6!}{3!}$$

A "Chopped" off factorial.

Simplify, then evaluate

$$\frac{7!}{4!} =$$

Simplify, then evaluate

$$\frac{7!}{4!} = \frac{7 \times 6 \times 5 \times 4!}{4!}$$

Simplify, then evaluate

$$\frac{7!}{4!} = \frac{7 \times 6 \times 5 \times 4!}{4!}$$

$$= 7 \times 6 \times 5$$

Simplify, then evaluate

$$\frac{7!}{4!} = \frac{7 \times 6 \times 5 \times 4!}{4!}$$

$$= 7 \times 6 \times 5$$

$$= 210$$

You have 5 different numbers, how many ways can they be arranged?

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5 x 4 x ? x ? x ?

You have 5 numbers, how many ways can they be arranged?

$$5 \times 4 \times 3 \times 2 \times 1$$

You have 5 numbers, how many ways can they be arranged?

5 x 4 x 3 x 2 x 1

Number of ways

= 5 x 4 x 3 x 2 x 1

= 5!

You have 5 numbers, how many ways can they be arranged?

5 x 4 x 3 x 2 x 1

Number of ways

= 5 x 4 x 3 x 2 x 1

= 5!

= 120

You have 10 different numbers, how many ways 4 unique digits be arranged on a licence plate?

The digits will not repeat in this example.

10 x 9 x 8 x 7

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10 x 9 x 8 x 7

$$10 \times 9 \times 8 \times 7 = \frac{10!}{6!}$$

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10 x 9 x 8 x 7

$$10 \times 9 \times 8 \times 7 = \frac{10!}{6!}$$

$$= 5{,}040$$