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- It is important to get the set of objects right.
- To do this, you must ask a good question: "In how many ways..."

A Simple Combinatorial Proof

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Another Simple Combinatorial Proof

Example. Prove *Equation* (2.4): $k\binom{n}{k} = n\binom{n-1}{k-1}$.

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Combinatorial Proof:

Question: In how many ways can we choose from n club members a committee of k members with a chairperson?

Answer 1:

Answer 2:

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Pascal's Identity

Example. Prove *Theorem* 2.2.1: $\binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1}$.

Combinatorial Proof:

Question: In how many ways can we choose k flavors of ice cream if n different choices are available?

Answer 1:

Answer 2:

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Summing Binomial Coefficients

Example. Prove *Equation* (2.3): $\binom{n}{0} + \binom{n}{1} + \binom{n}{2} + \cdots + \binom{n}{n} = 2^n$.

Analytic Proof: ???

Combinatorial Proof:

Question: How many subsets of $\{1, 2, \ldots, n\}$ are there?

Answer 1: Condition on how many elements are in a subset.

Answer 2:

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—Worksheet—

Tiling a board with dominos and squares

Question: How many ways are there to tile a $1 \times n$ board using only dominoes and squares?

Definition: Let $f_n = \#$ of ways to tile a $1 \times n$ board.

$f_0 = 1$
$f_1 =$
$f_2 =$
$f_3 =$
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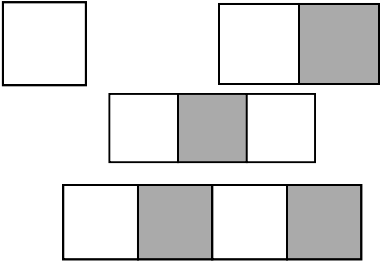

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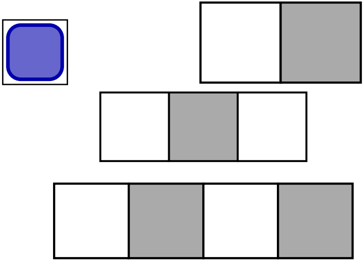

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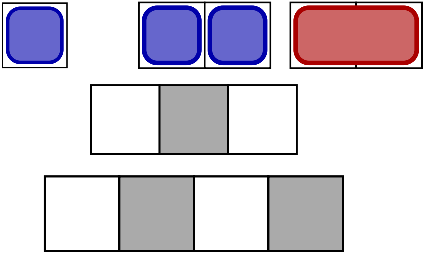

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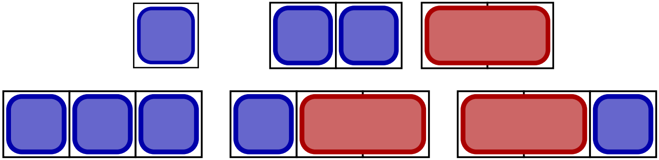

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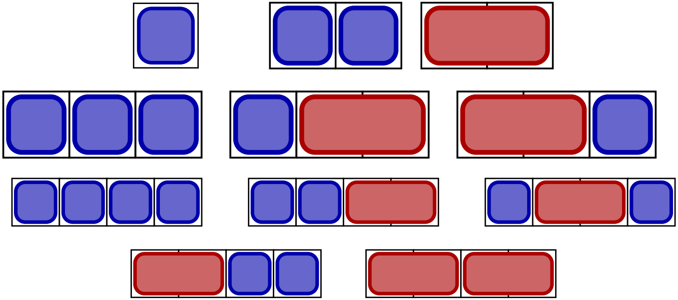

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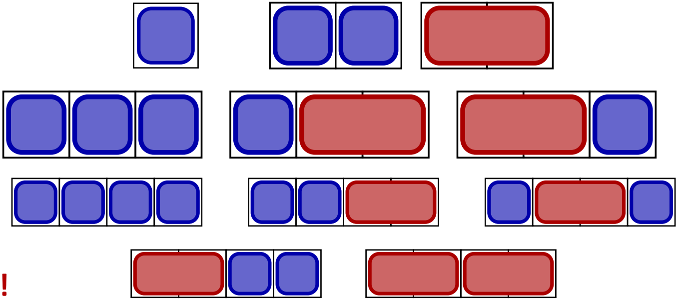

Fibonacci!

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Fibonacci numbers f_n satisfy

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Total: $f_{n-1} + f_{n-2}$

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  - **How many?** Fill the initial $1 \times (n-2)$ board in f_{n-2} ways.

Total: $f_{n-1} + f_{n-2}$

Fibonacci identities

We have a new definition for Fibonacci:

$f_n =$ the number of square-domino tilings of a $1 \times n$ board.

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1	2	**3**	**5**	8	13	21	**34**	55	89	144	233	377	610

$$f_8 = f_4^2 + f_3^2$$

$$34 = 25 + 9$$

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$$f_{14} = f_7^2 + f_6^2$$

$$610 = 441 + 169$$

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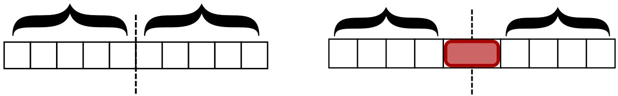
Answer 2. Ask whether there is a break in the middle of the tiling:

Either there is... Or there isn't...



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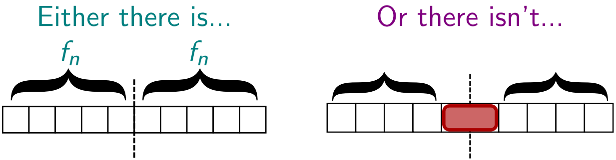

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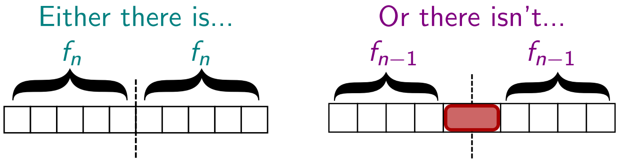

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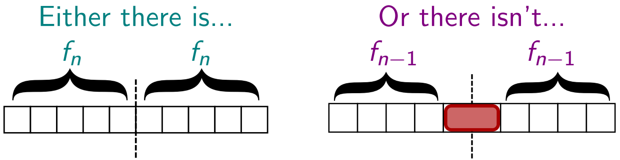

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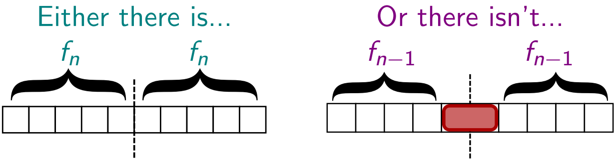

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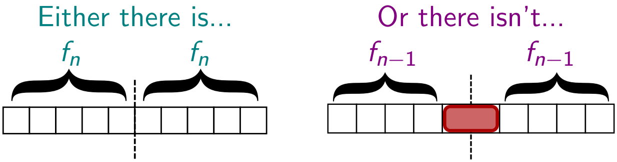

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Further reading:

Arthur T. Benjamin and Jennifer J. Quinn
Proofs that Really Count, MAA Press, 2003.