

Statistical Rethinking

Week 1

The Golem of Prague

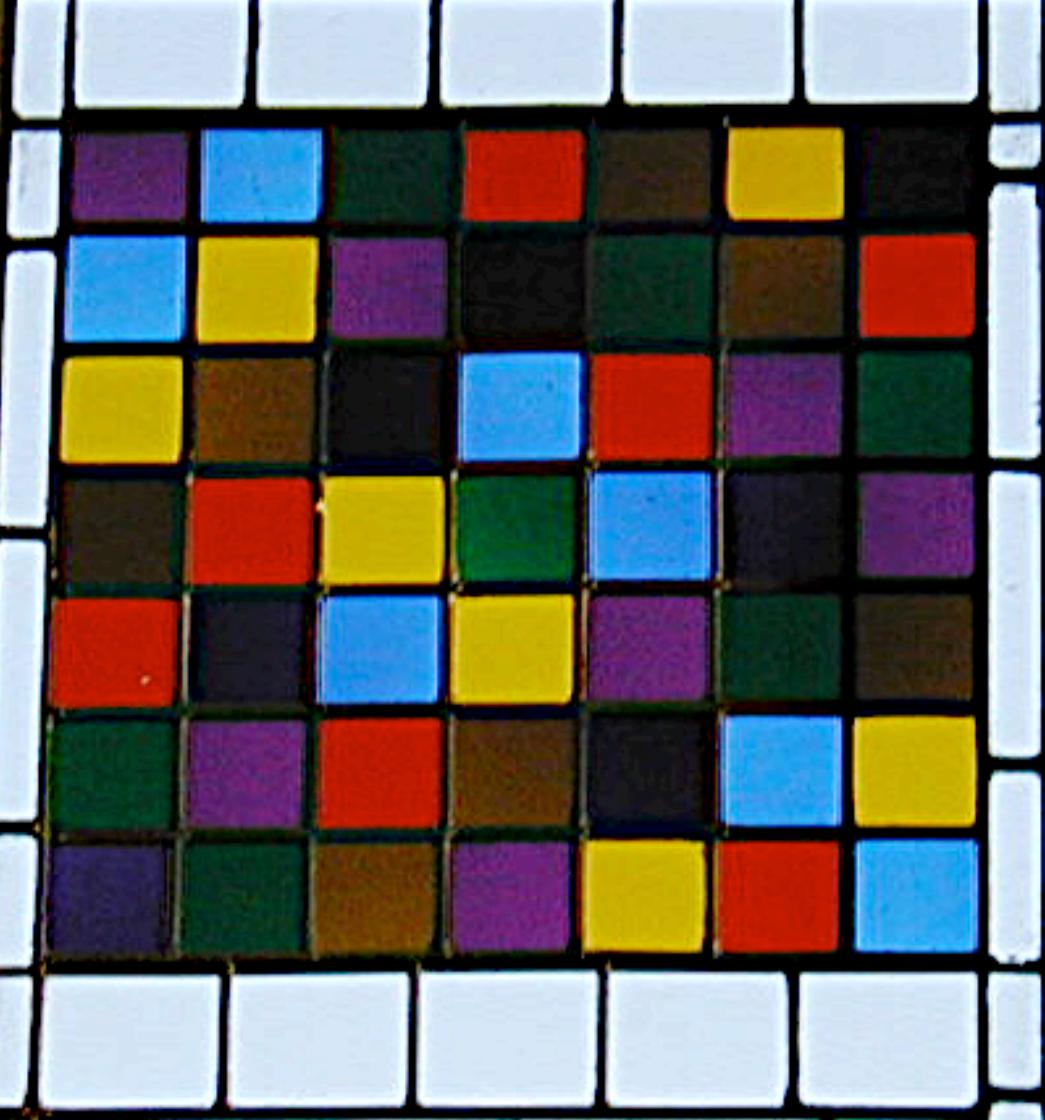
Topics

Week 1	Bayesian inference	Chapters 1, 2, 3
Week 2	Linear models	Chapter 4
Week 3	Multivariate models	Chapter 5
Week 4	Model comparison	Chapter 6
Week 5	Interactions	Chapter 7
Week 6	MCMC & GLMs	Chapters 8, 9, 10
Week 7	GLMs II	Chapters 10 & 11
Week 8	Multilevel models I	Chapter 12
Week 9	Multilevel models II	Chapter 13
Week 10	Measurement error etc.	Chapter 14



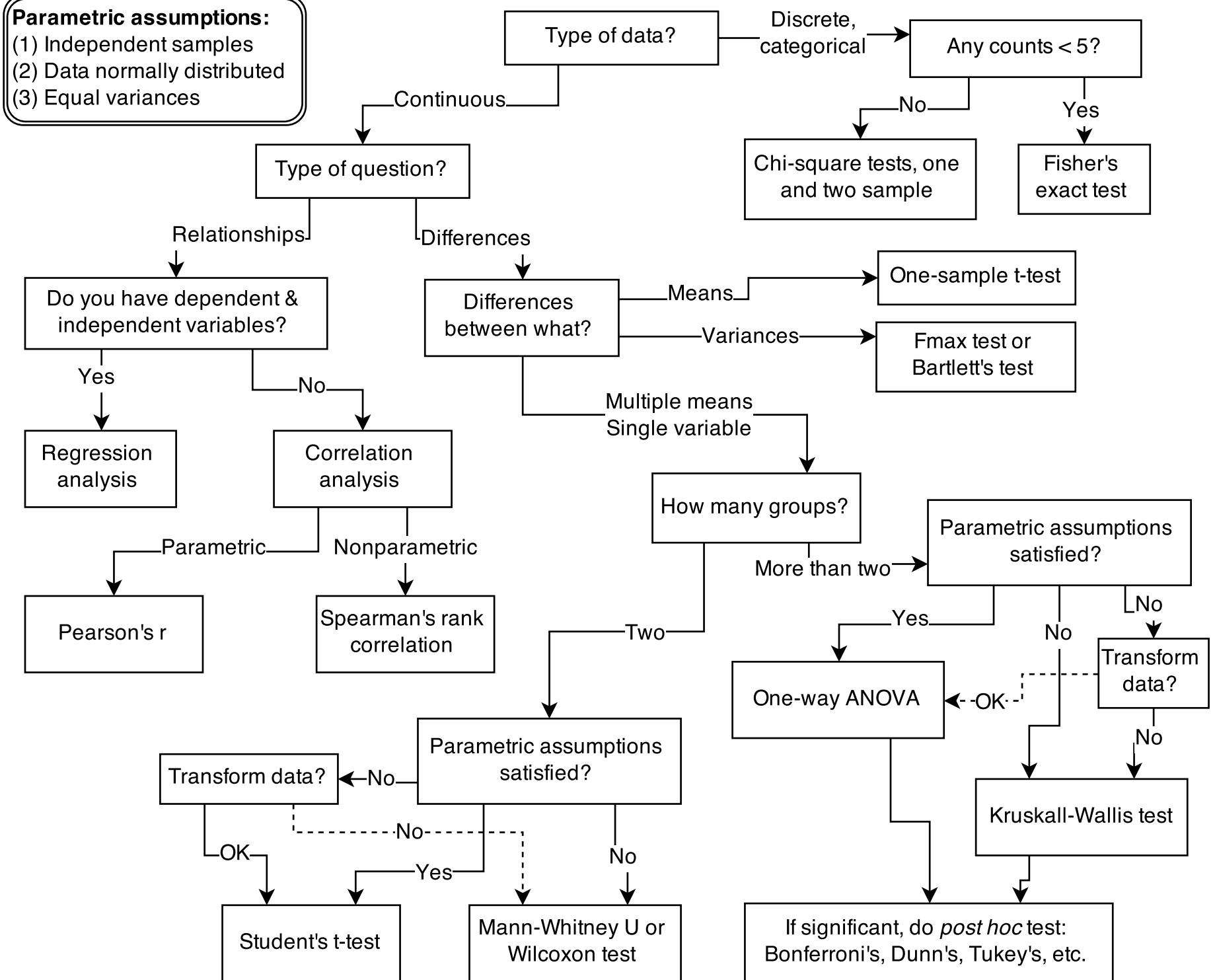
JJ Harrison, "Phylidonyris novaehollandiae Bruny Island"





R.A.FISHER
FELLOW 1920-26 1945-62
PRESIDENT 1956-59





The Golem of Prague

go•lem |gōləm|

noun

- (in Jewish legend) a clay figure brought to life by magic.
- an automaton or robot.

ORIGIN late 19th cent.: from Yiddish *goylem*, from Hebrew *gōlem* ‘shapeless mass.’



The Golem of Prague

- How-To:
 - (1) Get a ton of clay
 - (2) Form into humanoid
 - (3) Inscribe brow with *emeth*, “truth”
 - (4) Give commands, very carefully



The Golem of Prague

“Even the most perfect of Golem, risen to life to protect us, can easily change into a destructive force. Therefore let us treat carefully that which is strong, just as we bow kindly and patiently to that which is weak.”



Rabbi Judah Loew ben
Bezalel (1512–1609)



From *Breath of Bones: A Tale of the Golem*

The Golems of Science

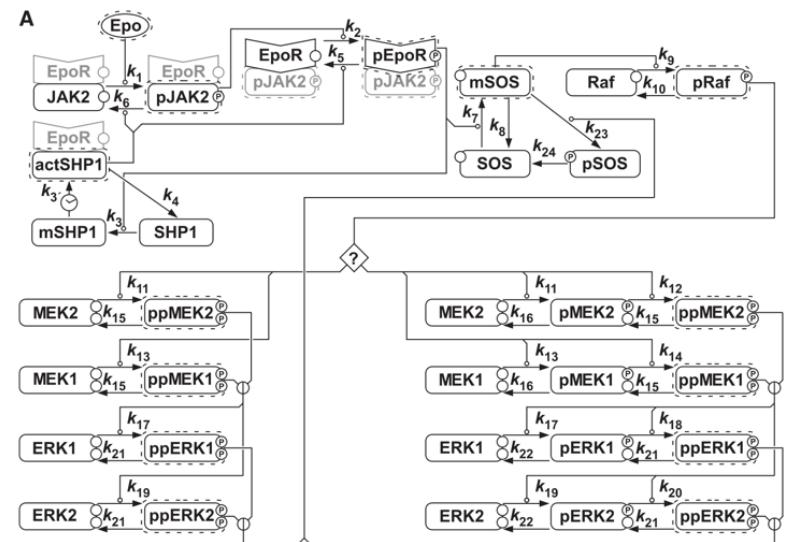
Golem

- Made of clay
- Animated by “truth”
- Powerful
- Blind to creator’s intent
- Easy to misuse
- Fictional



Model

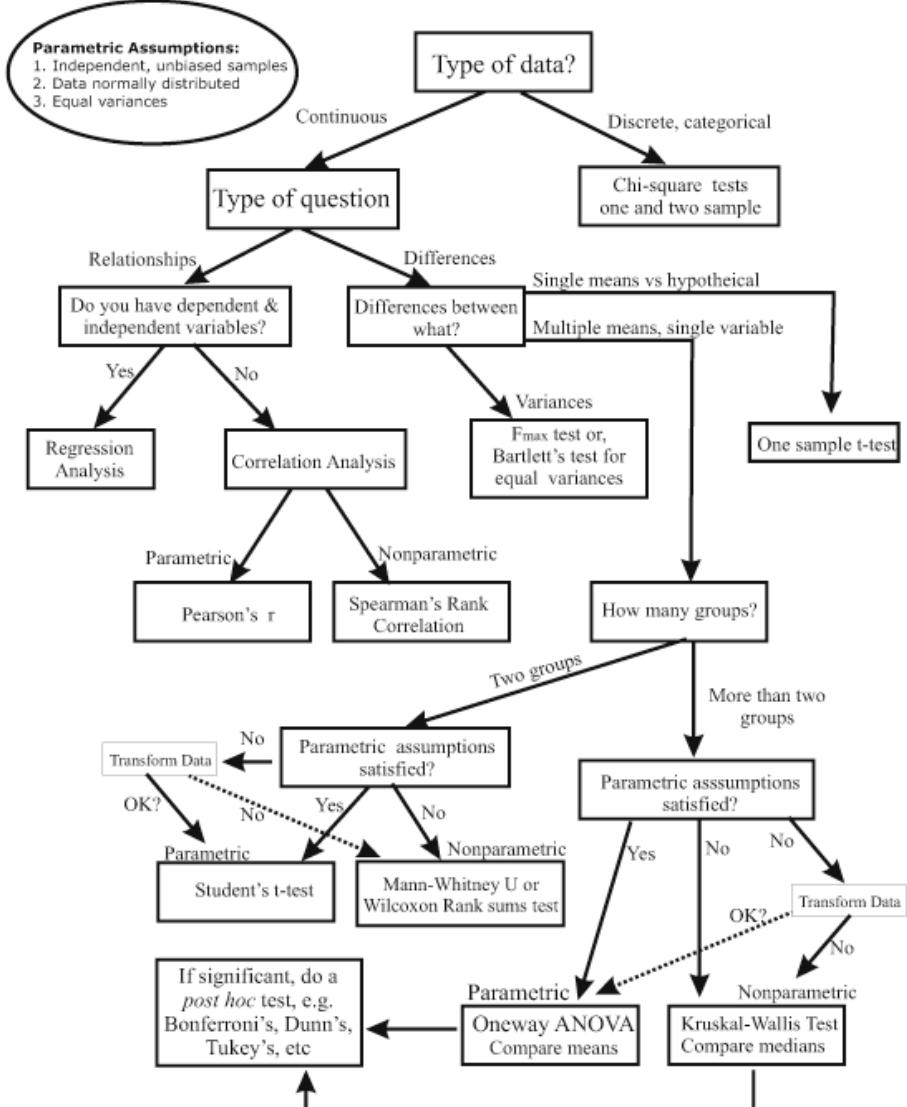
- Made of...silicon?
- Animated by “truth”
- Hopefully powerful
- Blind to creator’s intent
- Easy to misuse
- Not even false



Against Tests

- Specialized, pre-made golems, “procedures”
- Most developed in early 20th century, fragile, eclipsed by more recent tools
- Users don’t know they are using models
- Falsifying *null* model not sufficient

Flow Chart for Selecting Commonly Used Statistical Tests



O, that way madness lies

Hypotheses

Process models

Statistical models

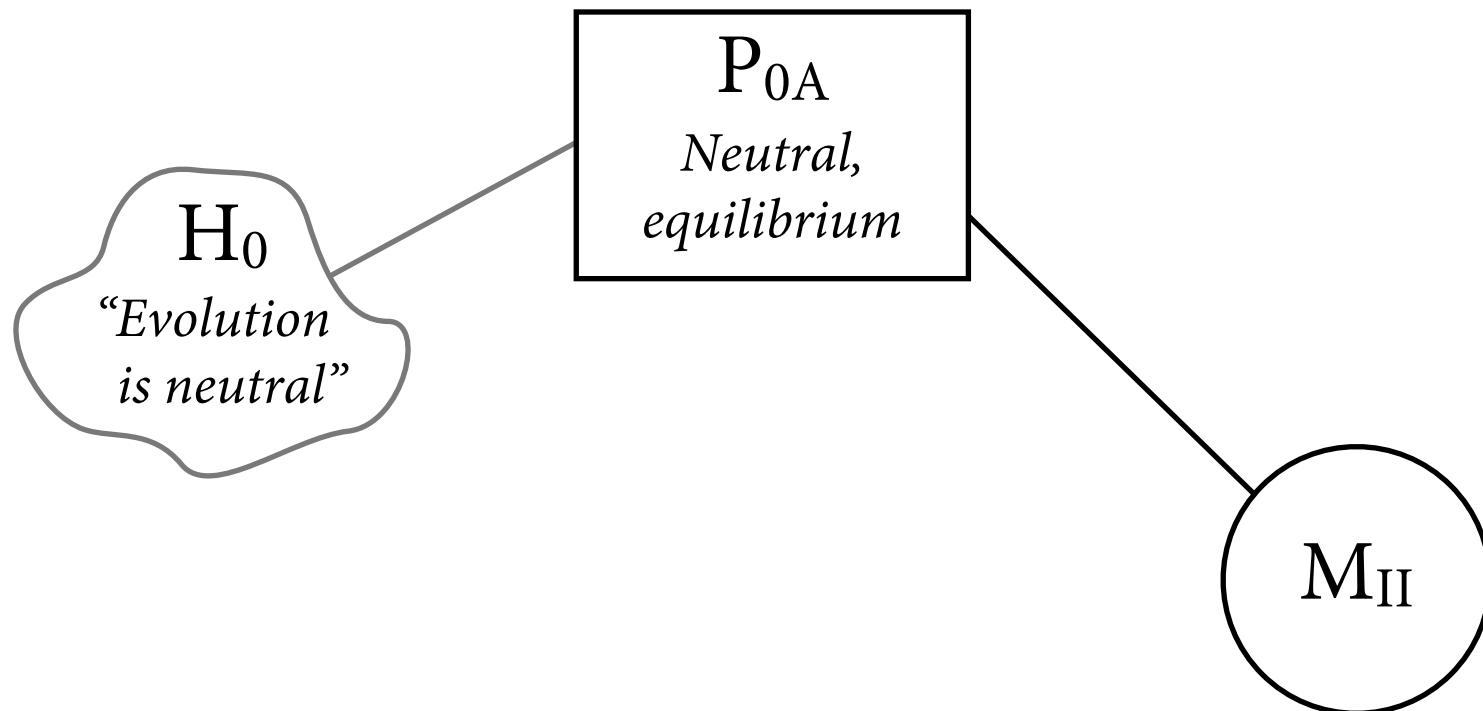


Figure 1.2

Hypotheses

Process models

Statistical models

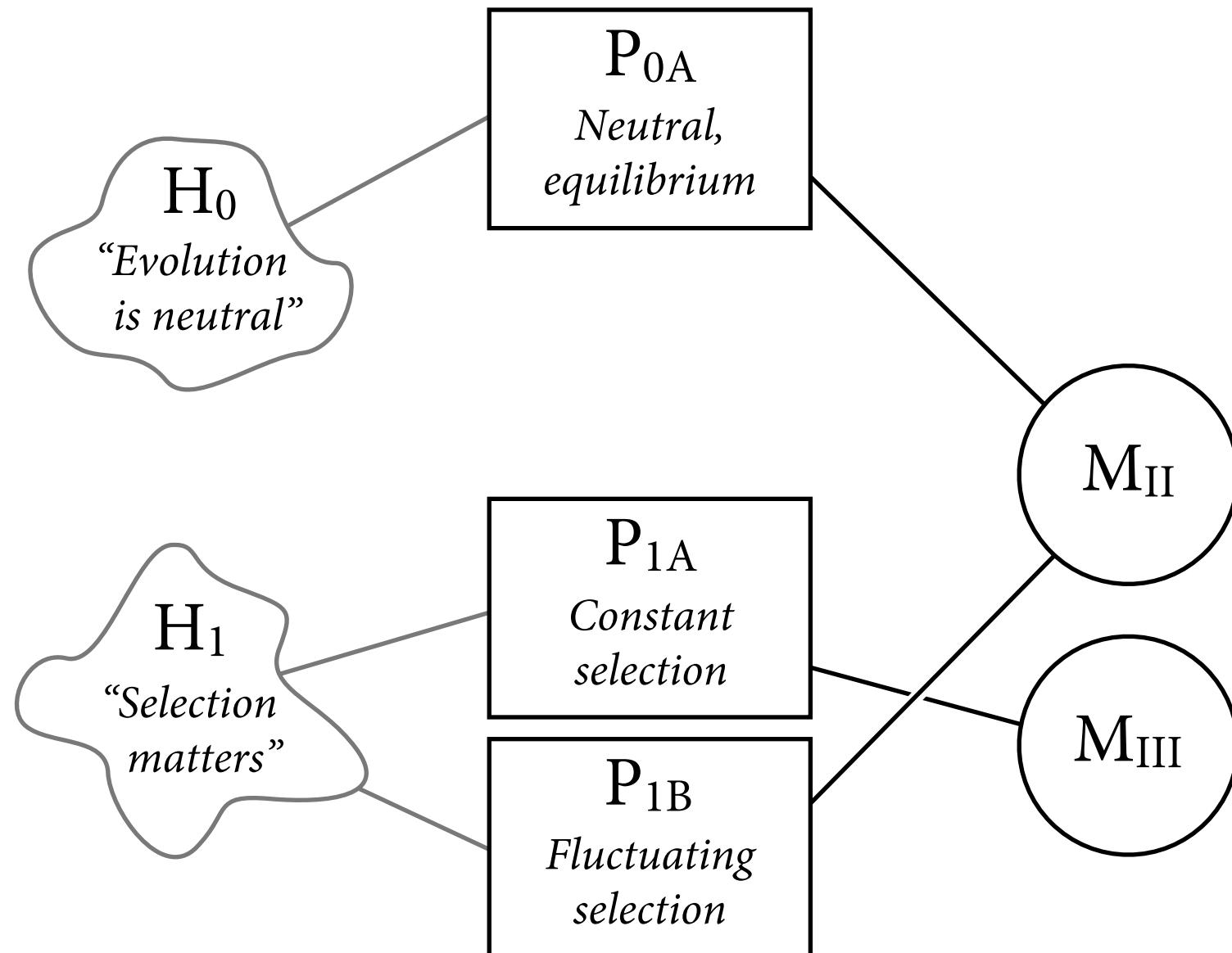


Figure 1.2

Hypotheses

Process models

Statistical models

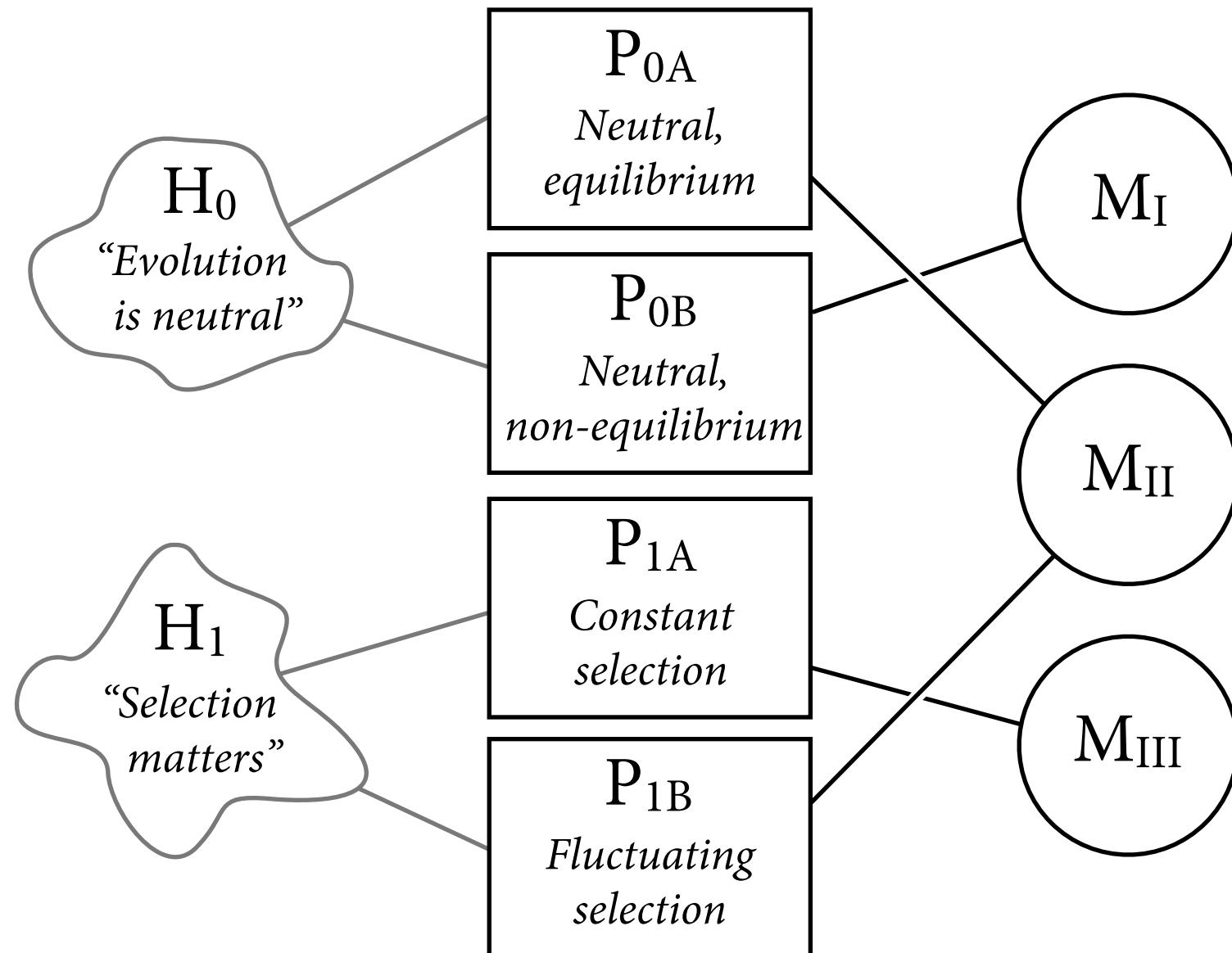


Figure 1.2

Failure of Falsification

- Null models not unique
- Should falsify *explanatory* model, not *null* model
- Falsification is *consensual*, not *logical*
- Falsifiability about *demarcation*, not method
- Science is a social technology



“There is even something like a methodological justification for individual scientists to be dogmatic and biased. Since **the method of science is that of critical discussion**, it is of great importance that the theories criticized should be tenaciously defended. For only in this way can we learn their real power.”

—Karl Popper, *The Myth of the Framework*

Golem Engineering

- Need a framework for developing and vetting statistical golems
- Several options
- We'll use this one
 - Bayesian data analysis
 - Multilevel modeling
 - Model comparison and information criteria



From *Breath of Bones: A Tale of the Golem*

Bayesian data analysis

- Use *probability* to describe uncertainty
 - Extends propositional logic (true/false) to continuous *plausibility*
- Computationally difficult
 - Markov chain Monte Carlo (MCMC) to the rescue
- Used to be controversial
 - Ronald Fisher: Bayesian analysis “must be wholly rejected.”



Pierre-Simon Laplace (1749–1827)



Sir Harold Jeffreys (1891–1989)
with Bertha Swirles, aka Lady
Jeffreys (1903–1999)

Bayesian data analysis

*Count all the ways data can happen,
according to assumptions.*

*Assumptions with more ways to
cause data are more plausible.*

Bayesian data analysis

- Contrast with *frequentist* view
 - Probability is just limiting frequency
 - Uncertainty arises from *sampling variation*
- Bayesian probability much more general
 - Probability is in the golem, not in the world
 - Coins are not random, but our ignorance makes them so



Saturn as Galileo saw it

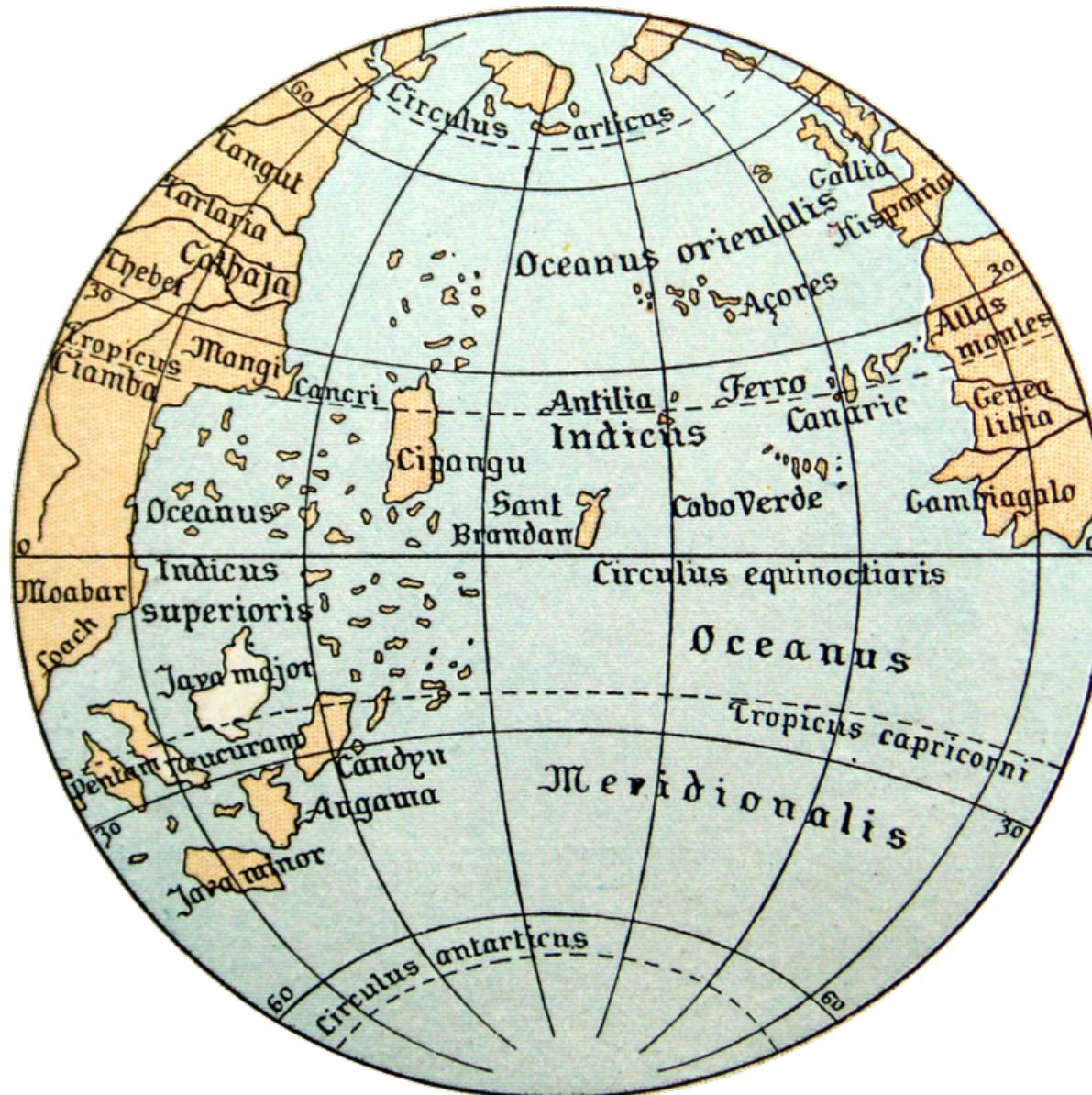
Statistical Rethinking

Week 1

Small Worlds and Large Worlds

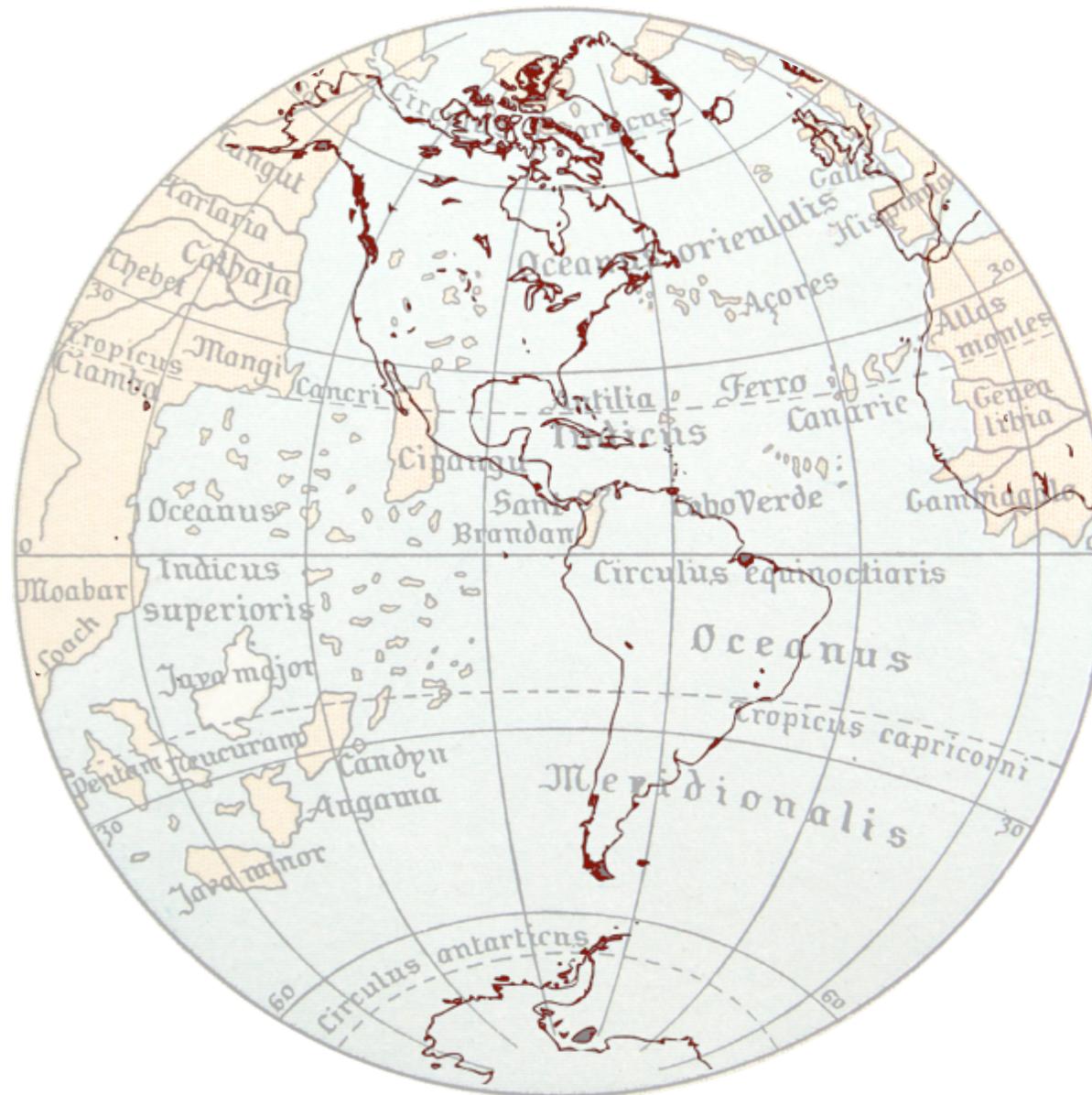
(Chapter 2)

Colombo's Mistake



Behaim's globe, as detailed in 1492

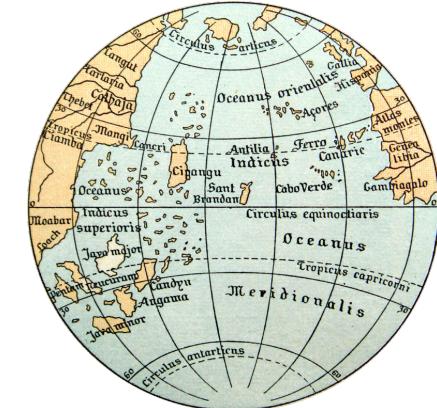
Colombo's Mistake



Behaim's globe, as detailed in 1492

Small and Large Worlds

- *Sensu* L.J. Savage (1954)
 - **Small world:** The world of the golem's assumptions. Bayesian golems are optimal, in the small world.
 - **Large world:** The real world. No guarantee of optimality for any kind of golem.
- Have to worry about both



Bayesian data analysis

*Count all the ways data can happen,
according to assumptions.*

*Assumptions with more ways to
cause data are more plausible.*

Garden of Forking Data

- The future:
 - Full of branching paths
 - Each choice closes some
- The data:
 - Many possible events
 - Each observation eliminates some



Garden of Forking Data



Contains 4 marbles

Possible contents:

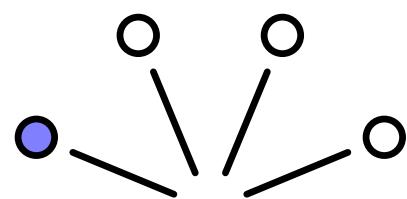
- (1) ○○○○
- (2) ●○○○
- (3) ●●○○
- (4) ●●●○
- (5) ●●●●

Observe:



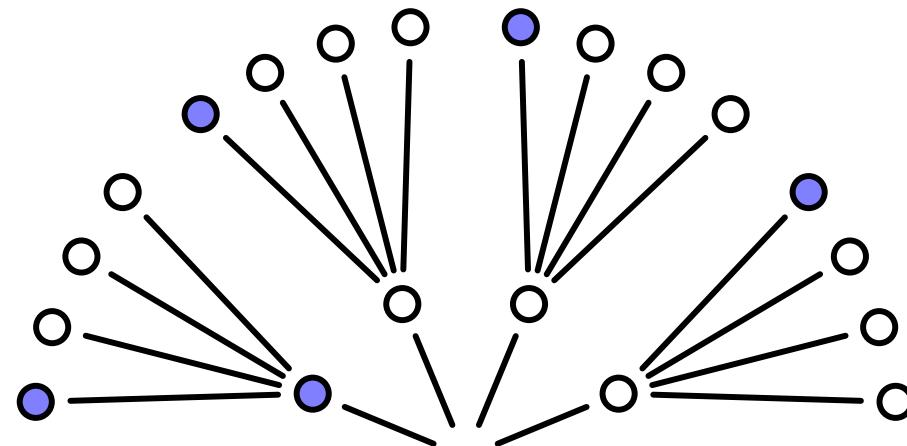
Conjecture: 

Data: 



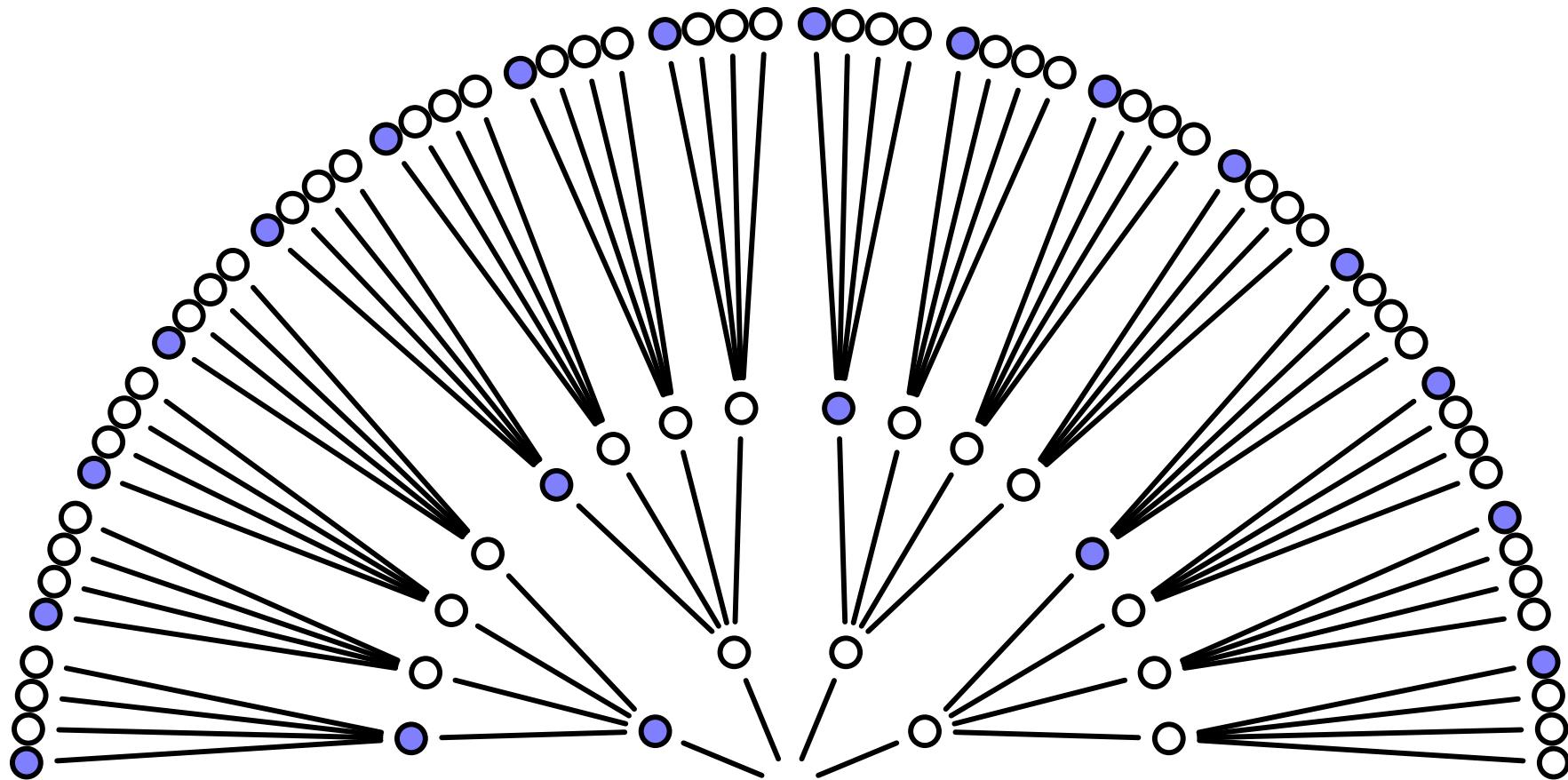
Conjecture: ● ○ ○ ○

Data: ● ○ ○



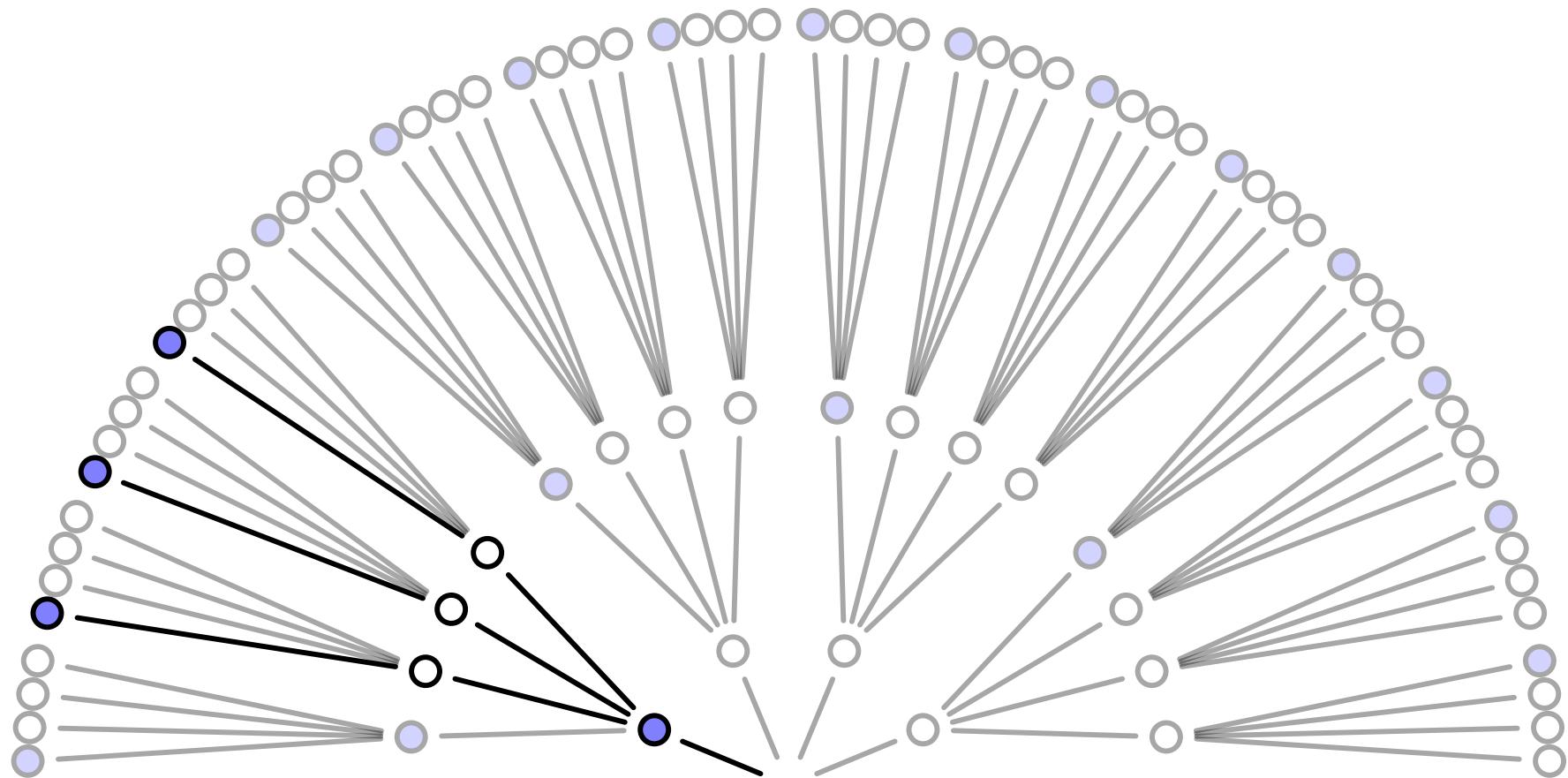
Conjecture: 

Data: 



Conjecture: 

Data: 



3 paths consistent with data

Garden of Forking Data

Possible contents:

- (1) ?
- (2) 3
- (3) ?
- (4) ?
- (5) ?

Ways to produce

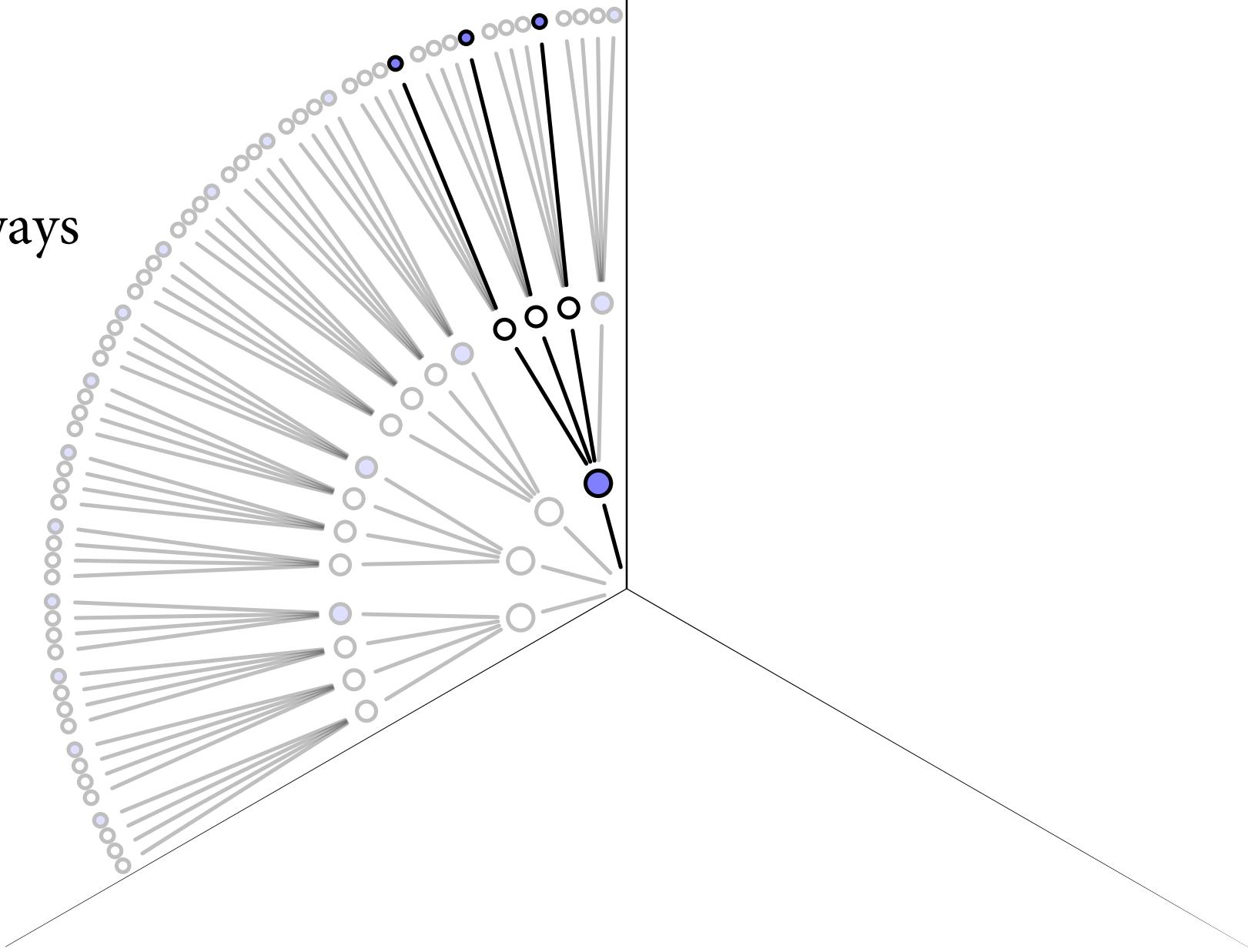
Garden of Forking Data

Possible contents:

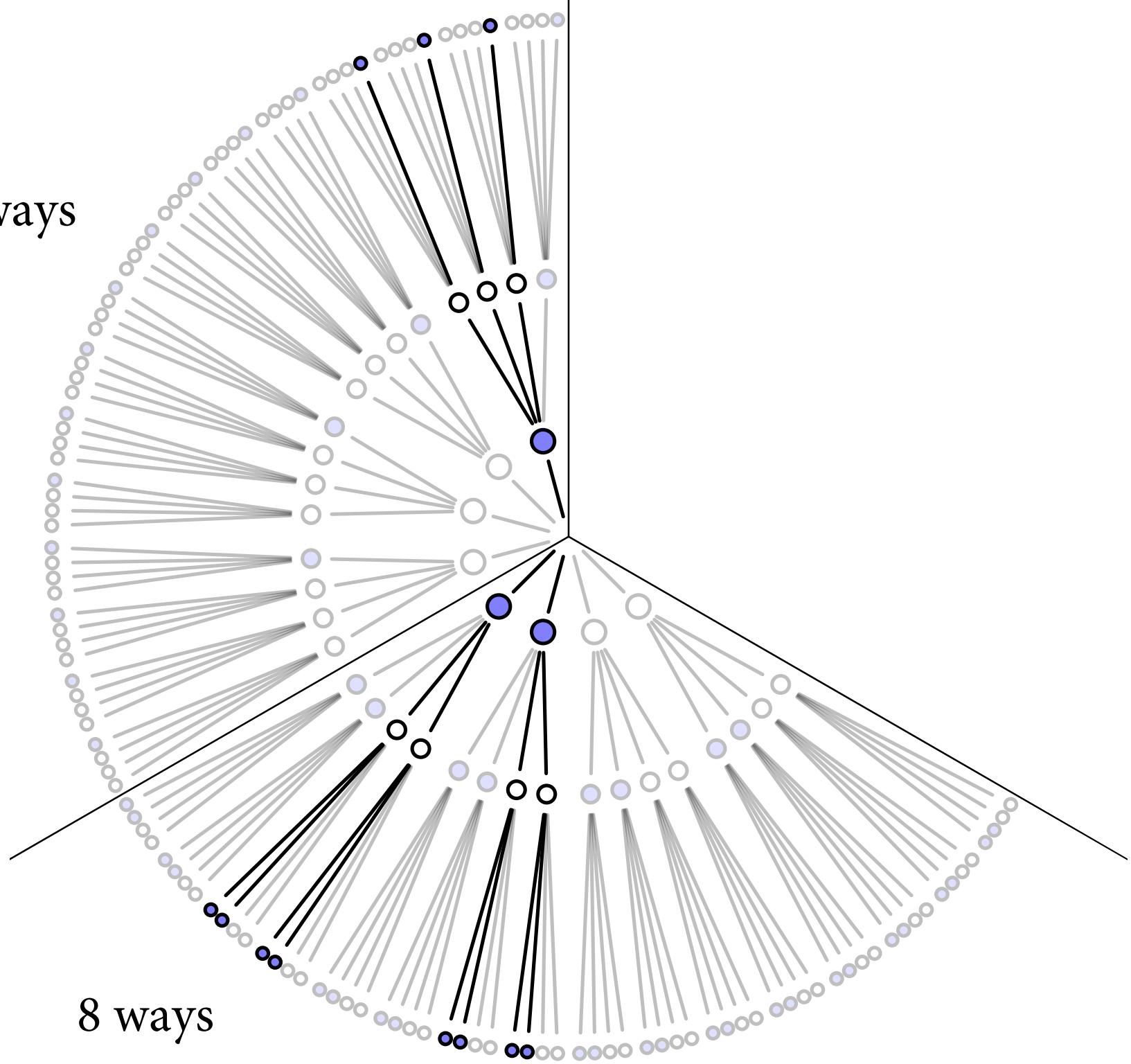
- (1) 0
- (2) 3
- (3) ?
- (4) ?
- (5) 0

Ways to produce

3 ways

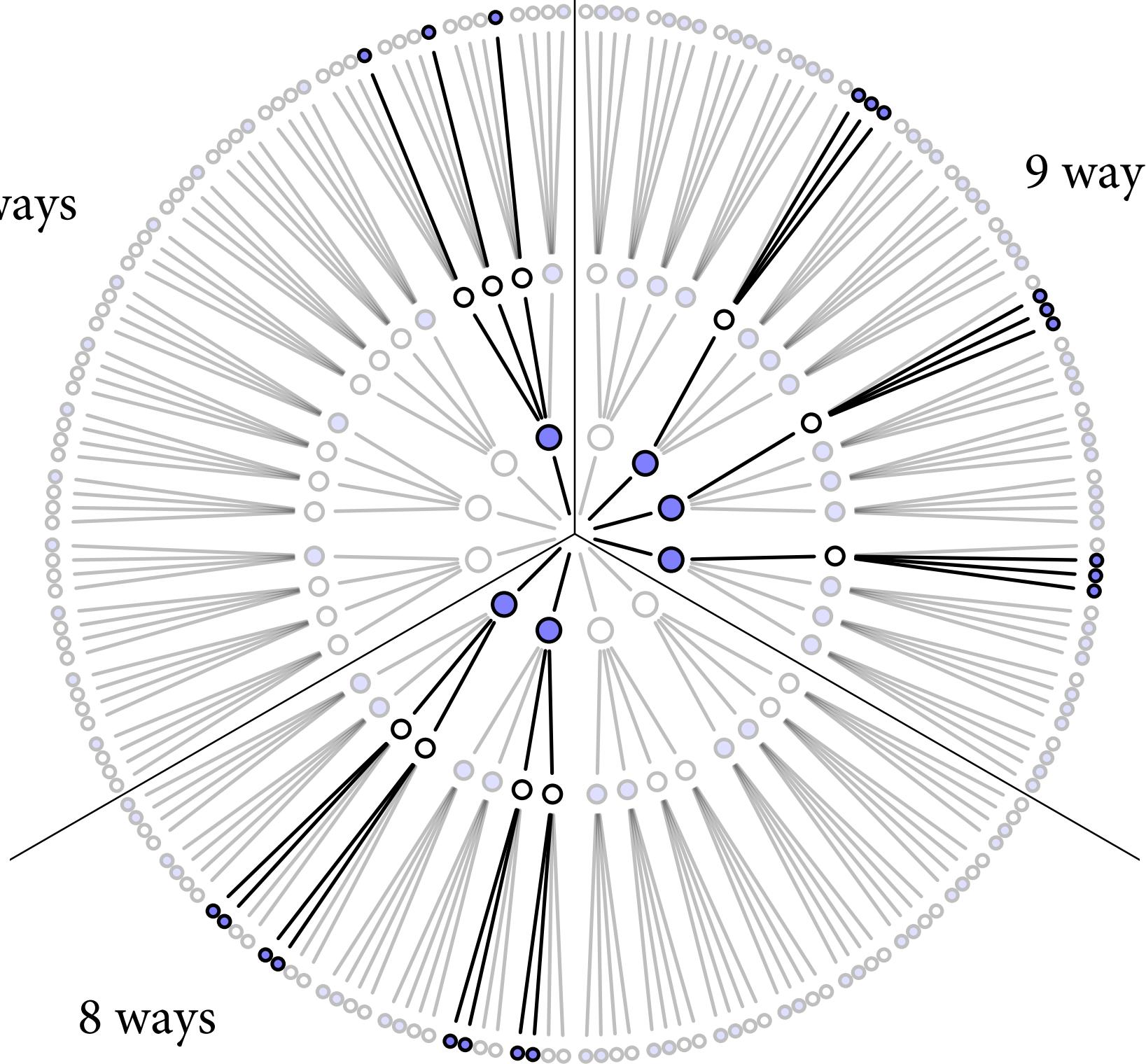


3 ways



8 ways

3 ways



8 ways

9 ways

Garden of Forking Data

Conjecture	Ways to produce 
[○○○○]	$0 \times 4 \times 0 = 0$
[●○○○]	$1 \times 3 \times 1 = 3$
[●●○○]	$2 \times 2 \times 2 = 8$
[●●●○○]	$3 \times 1 \times 3 = 9$
[●●●●○]	$4 \times 0 \times 4 = 0$

