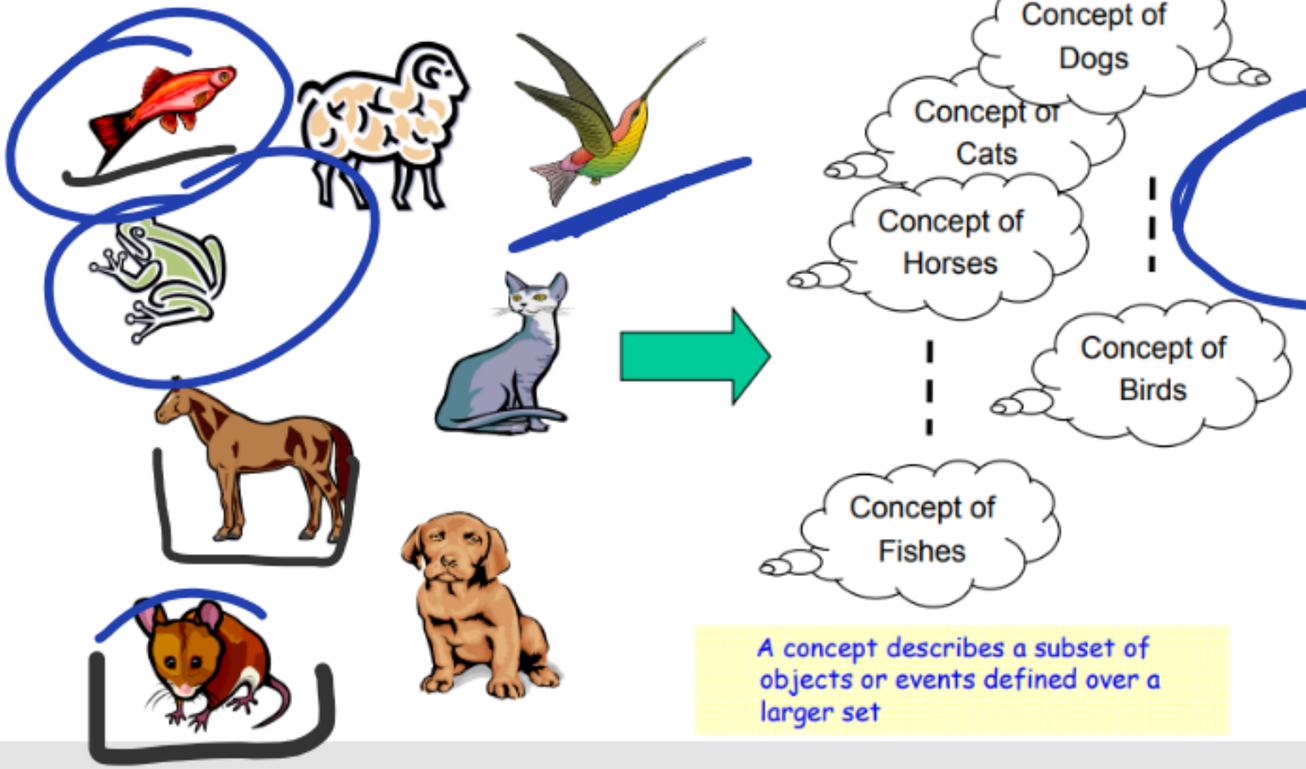
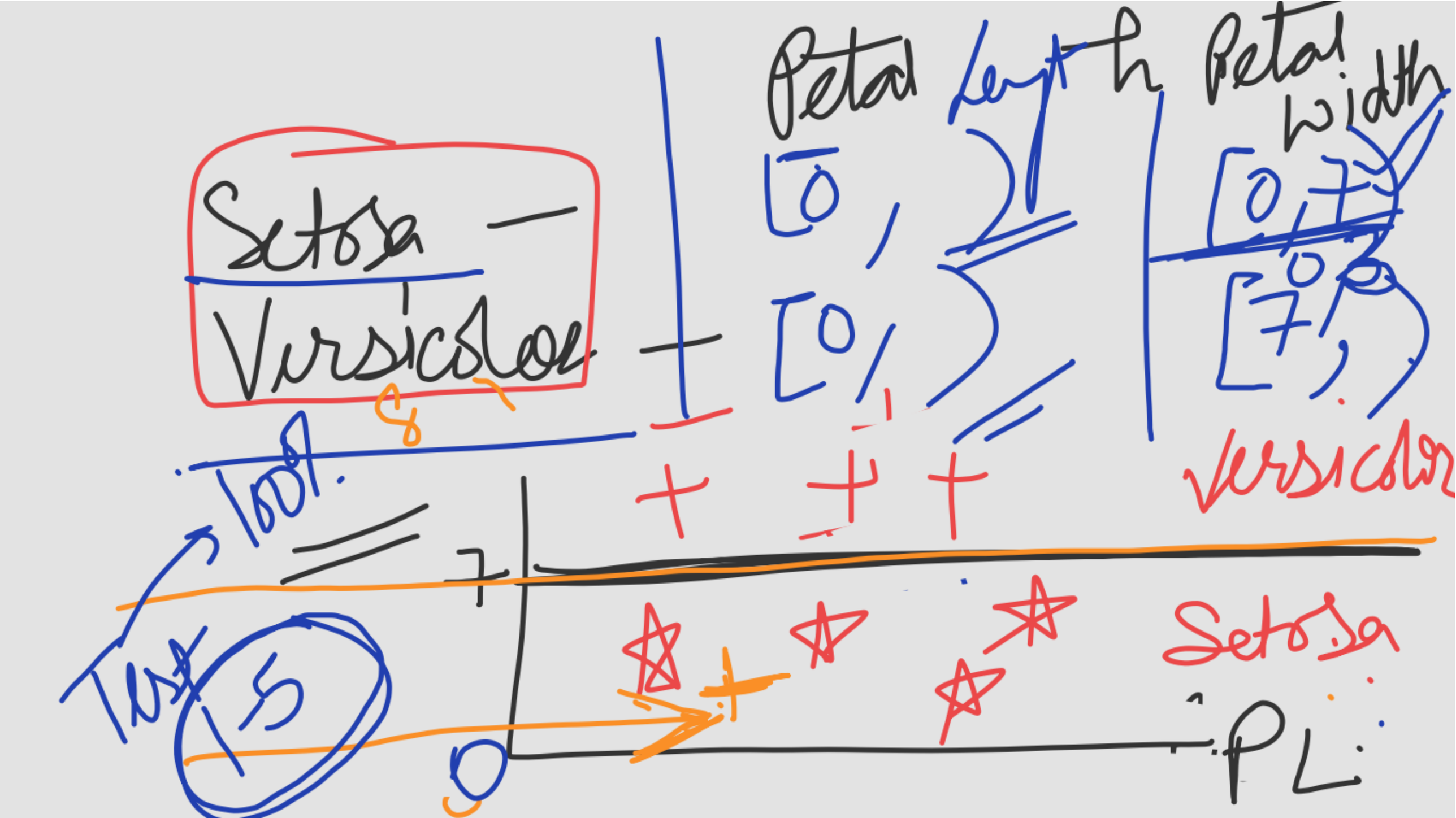
Chapter-2 Concept Learning and the General-to-Specific Ordering

What is a Concept ?



A concept describes a subset of objects or events defined over a larger set


Setosa
Versicolor
Petal Length
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[0,
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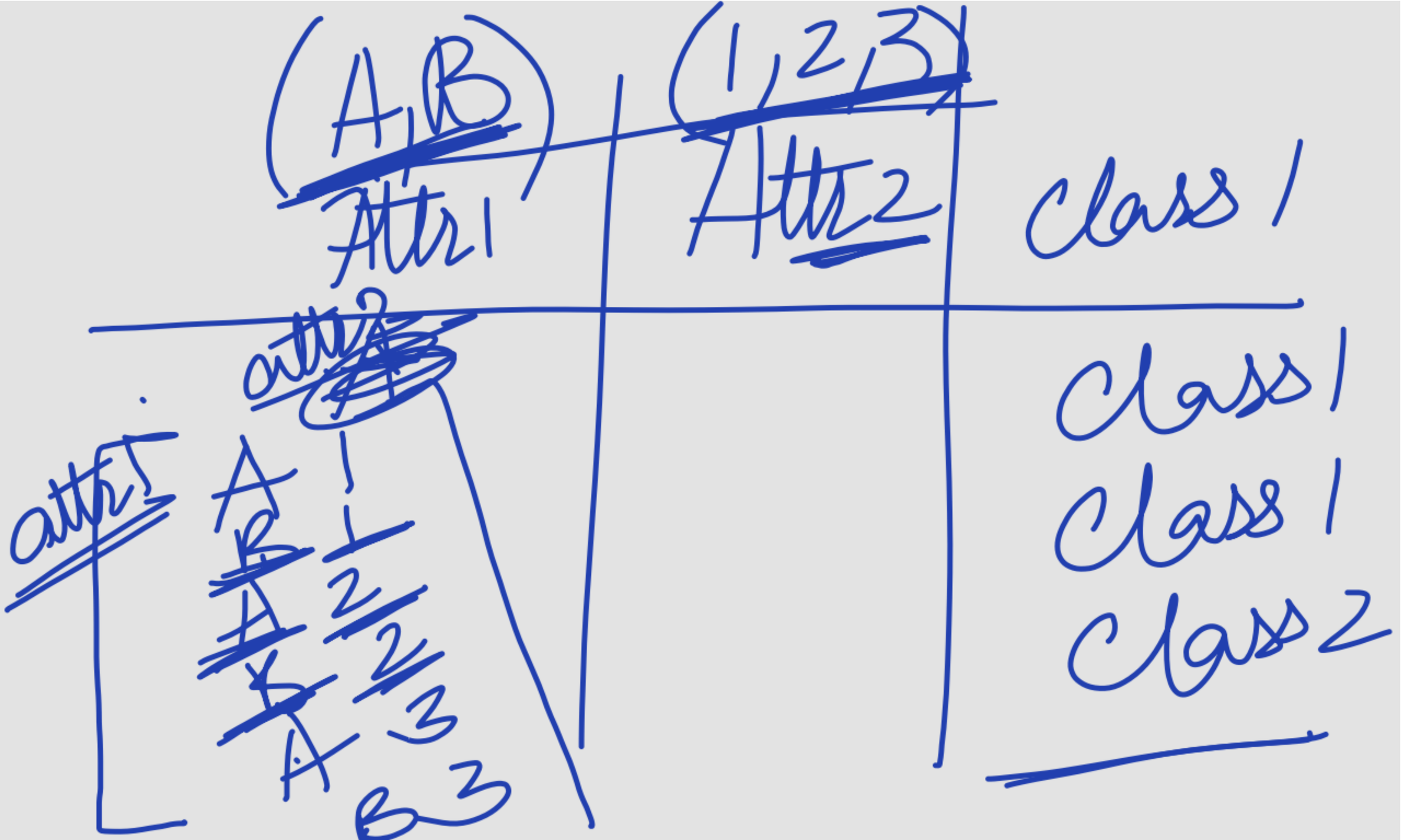
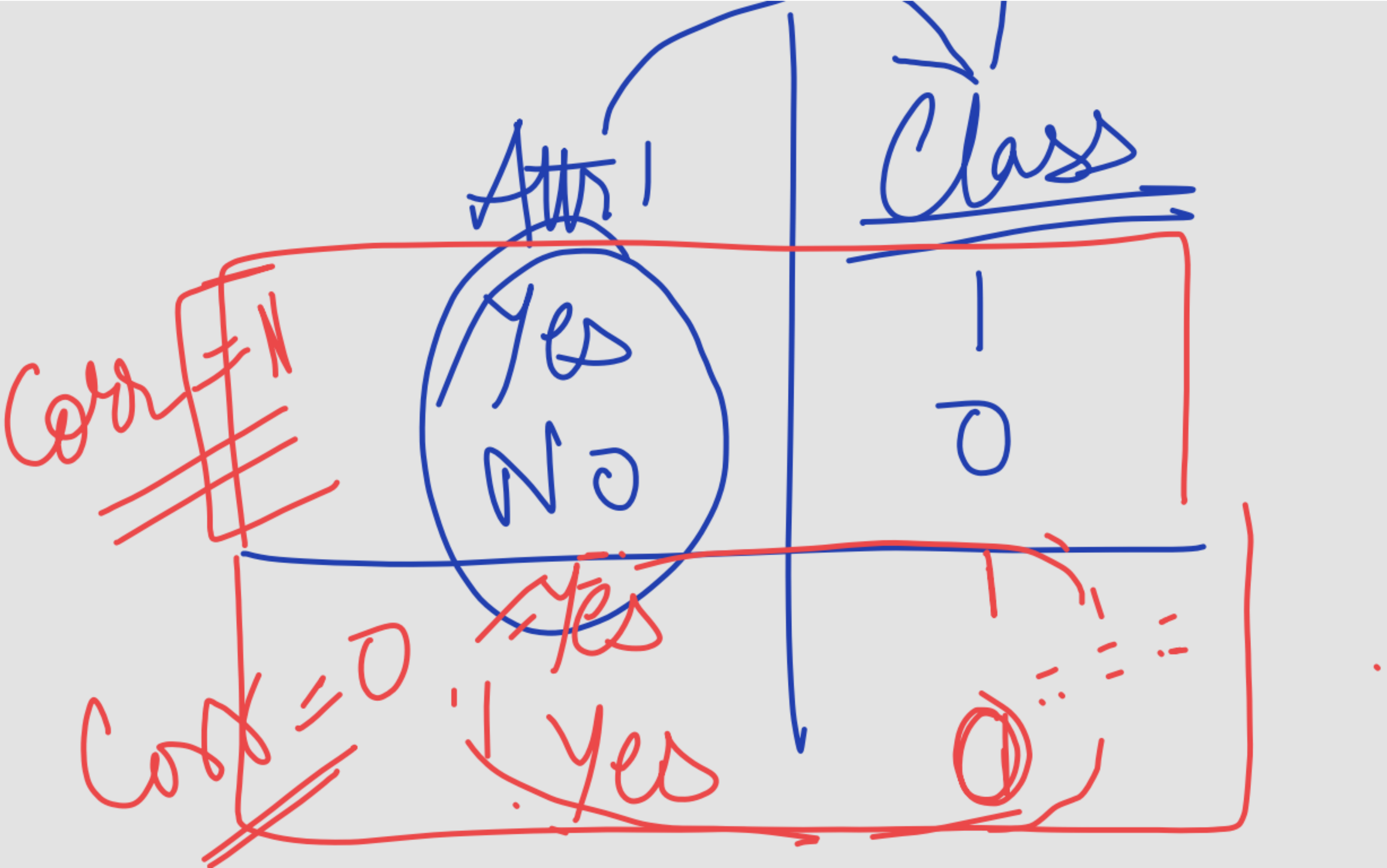
Versicolor
Test
Setosa
PL


(A,B)
Attr1
(1,2,3)
Attr2
class 1
attr1
A
B
A
B
1
2
2
3
3
class 1
class 1
class 2

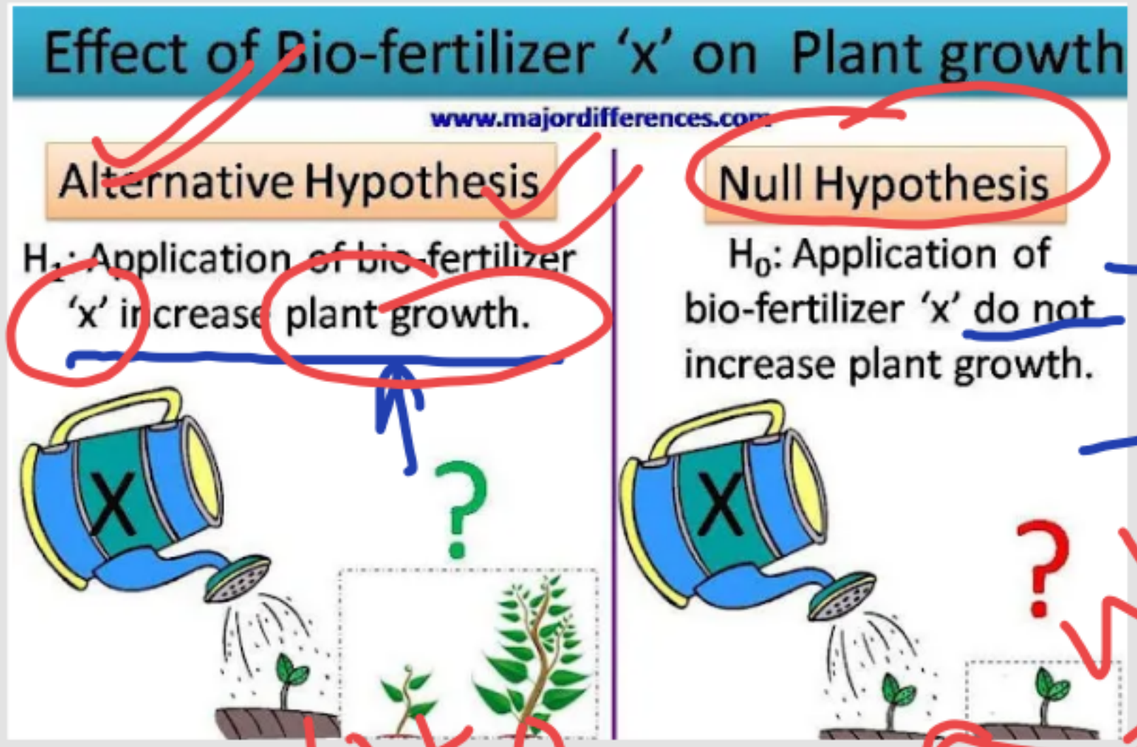
(Vertebrate Dataset)

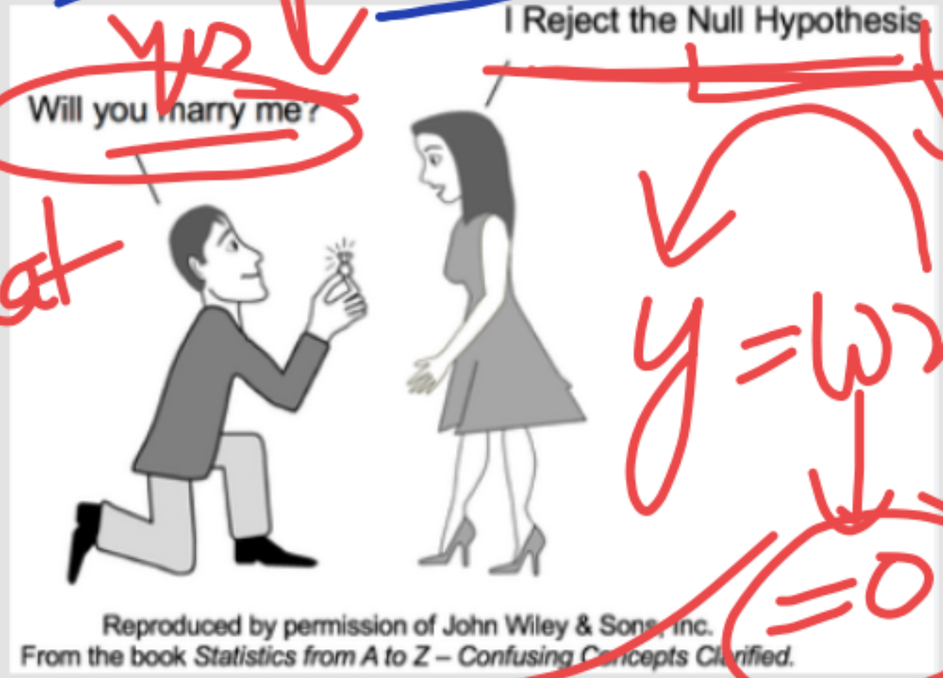
Name	Blood Type	Give Birth	Can Fly	Live in Water	Class
human	warm	yes	no	no	mammals
python	cold	no	no	no	reptiles
salmon	cold	no	no	yes	fishes
whale	warm	yes	no	yes	mammals
frog	cold	no	no	sometimes	amphibians
komodo	cold	no	no	no	reptiles
bat	warm	yes	yes	no	mammals
pigeon	warm	no	yes	no	birds
cat	warm	yes	no	no	mammals
leopard shark	cold	yes	no	yes	fishes
turtle	cold	no	no	sometimes	reptiles
penguin	warm	no	yes	sometimes	birds
porcupine	warm	yes	no	no	mammals
eel	cold	no	no	yes	fishes
salamander	cold	no	no	sometimes	amphibians
gila monster	cold	no	no	no	reptiles
platypus	warm	no	no	no	mammals
owl	warm	no	yes	no	birds
dolphin	warm	yes	no	yes	mammals
eagle	warm	no	yes	no	birds

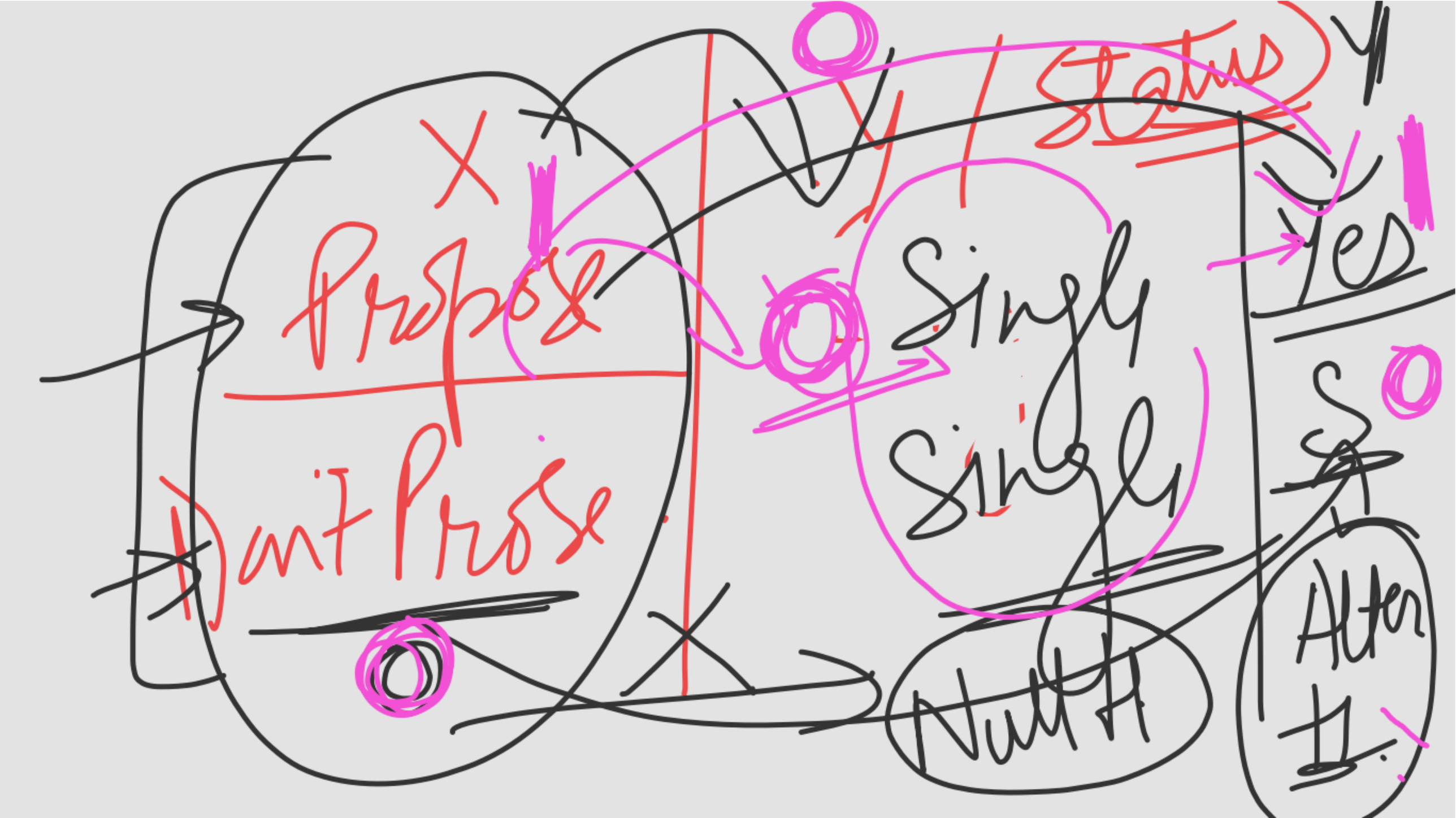

Class
Attr 1
Yes
No
1
0
Corr = N
Corr = 0
Yes
Yes
1
0

A hypothesis is an assumption, an idea that is proposed for the sake of argument so that it can be tested to see if it might be true.

The null hypothesis of a test always predicts no effect or no relationship between variables, while the alternative hypothesis states your research prediction of an effect or relationship.






X
Prepose
Don't Prose
Status
Singly
Singly
Null H
Yes
So
Alter
It

Concept Learning

For a particular concept (or category)

"Inferring a Boolean valued function from training examples of its input & Output

also known as hypothesis

Task: To learn the concept:

"On which days, Aldo enjoys his fav. Sports."

or

h = < Sunny, ?, ?, ?, ?, ? >

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
1	Sunny	Warm	Normal	Strong	Warm	Same	Yes
2	Sunny	Warm	High	Strong	Warm	Same	Yes
3	Rainy	Cold	High	Strong	Warm	Change	No
4	Sunny	Warm	High	Strong	Cool	Change	Yes

Yes

Category

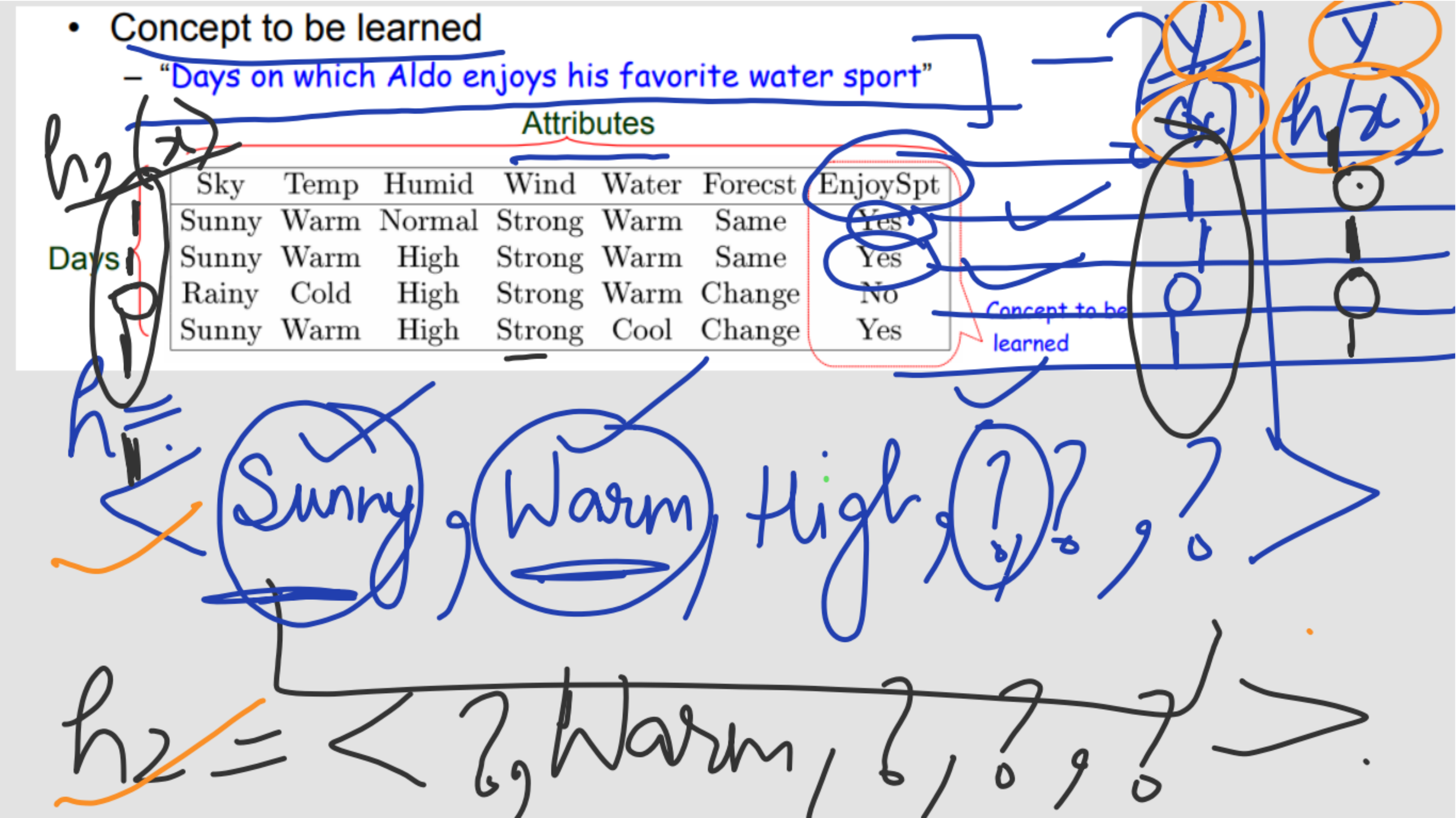
- Concept to be learned
  - "Days on which Aldo enjoys his favorite water sport"

Attributes

Sky	Temp	Humid	Wind	Water	Forecst	EnjoySpt
Sunny	Warm	Normal	Strong	Warm	Same	Yes
Sunny	Warm	High	Strong	Warm	Same	Yes
Rainy	Cold	High	Strong	Warm	Change	No
Sunny	Warm	High	Strong	Cool	Change	Yes

Days

Concept to be learned



Hypothesis : Conjunction of constraints on attributes

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
1	Sunny	Warm	Normal	Strong	Warm	Same	Yes
2	Sunny	Warm	High	Strong	Warm	Same	Yes
3	Rainy	Cold	High	Strong	Warm	Change	No
4	Sunny	Warm	High	Strong	Cool	Change	Yes

+ve class → 1
-ve class → 0

h : <Sunny, ?, ?, ?, ?, ?>

Permissible values for each attribute in hypothesis

*) ? → any value

*) ϕ → no value is acceptable

*) Single value — Sunny

Hypothesis : Conjunction of constraints on attributes

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
1	Sunny	Warm	Normal	Strong	Warm	Same	Yes 1
2	Sunny	Warm	High	Strong	Warm	Same	Yes 1
3	Rainy	Cold	High	Strong	Warm	Change	No 0
4	Sunny	Warm	High	Strong	Cool	Change	Yes 1

+ve class

-ve class

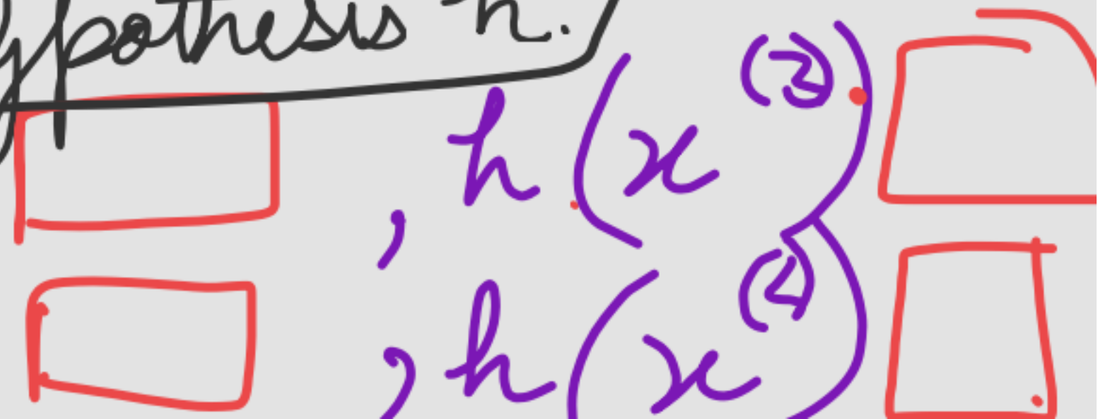
h :

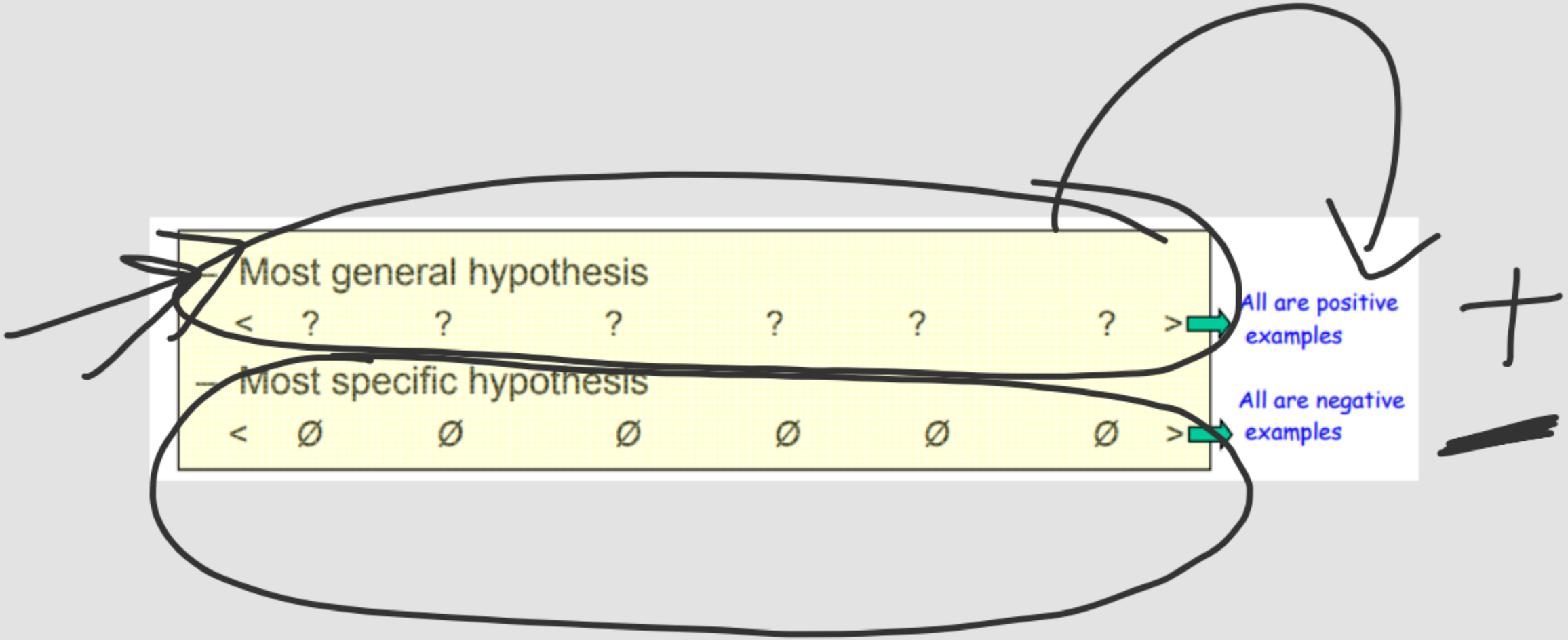
Classify any instance x as +ve class only if x satisfies all the constraints of hypothesis h.

$h(x) = 1$

Ques What is $h(x^{(1)})$, $h(x^{(3)})$

$h(x^{(2)})$, $h(x^{(4)})$




Most general hypothesis
< ? ? ? ? ? ? >
Most specific hypothesis
< Ø Ø Ø Ø Ø Ø >
All are positive examples
All are negative examples

Goal: To hypothesize or estimate Class c (binary class)

OR

To find hypothesis h such that
- $h(x) = c(x)$ for all x in X.

predicted value → actual value/class

Inductive learning hypothesis

Aim: To learn a hypothesis that best fits the observed training data and also approximates unseen/unobserved instances well.

test

- Concept learning can be viewed as the task of searching through a large space of hypotheses

Instance space *X*

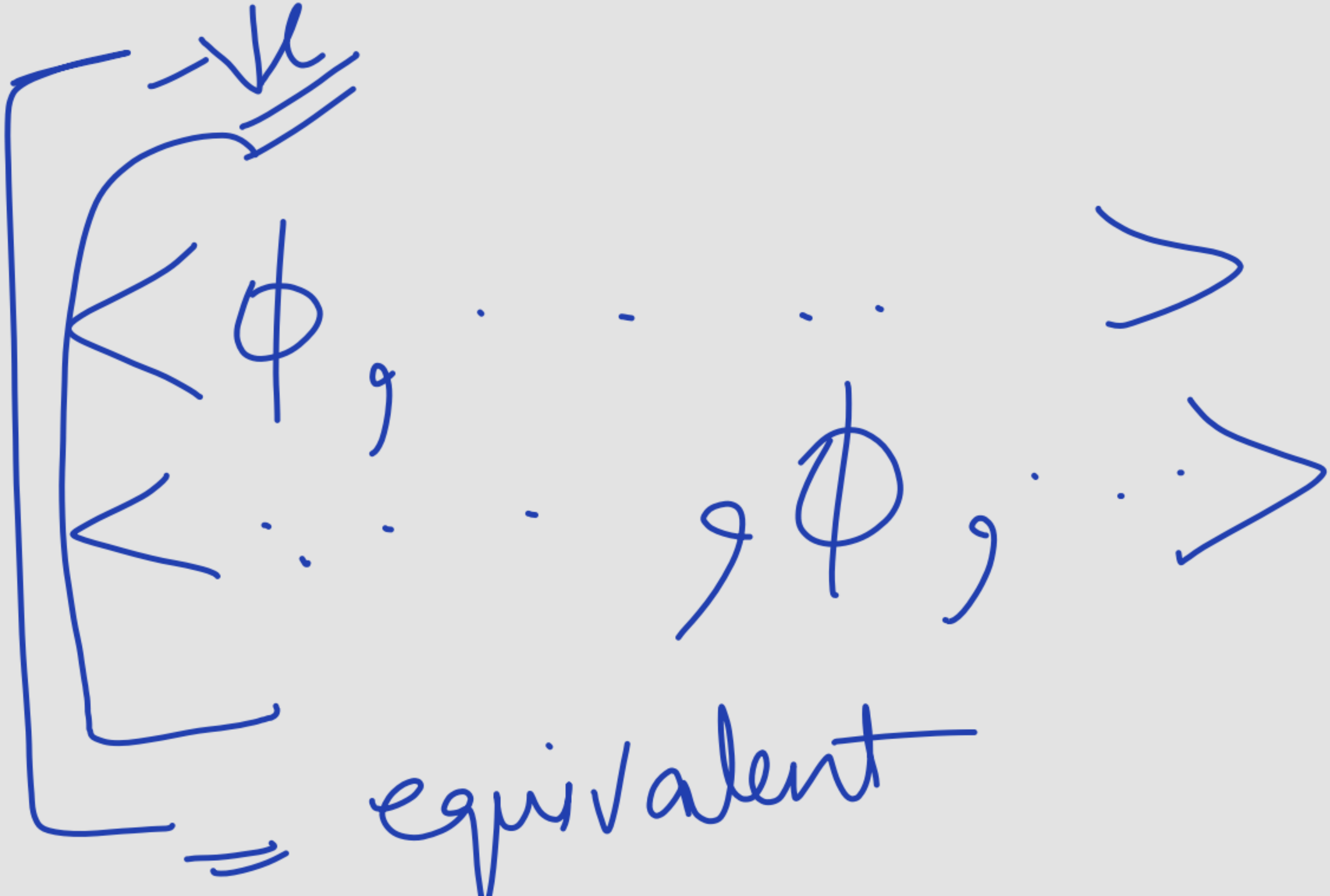
Sky (*Sunny/Cloudy/Rainy*)
AirTemp (*Warm/Cold*)
Humidity (*Normal/High*)
Wind (*Strong/Weak*)
Water (*Warm/Cool*)
Forecast (*Same/Change*)

No. of instances?

3 * 2 * 2 * 2 * 2 * 2

No. of Hypothesis in Hypothesis Space H?

5 * 4 * 4 * 4 * 4 * 4


equivalent

General to Specific ordering of Hypothesis

h_1 = <Sunny, ?, ?, Strong, ?, ?>

h_2 = <Sunny, ?, ?, ?, ?, ?> ✓

Which one is more general hypothesis?

h_2 ✓

Zebra [No of legs = 4]

Zebra [No of legs = 4, White & Black stripe]

(Vertebrate Dataset)

Name	Blood Type	Give Birth	Can Fly	Live in Water	Class
human	warm	yes	no	no	mammals
python	cold	no	no	no	reptiles
salmon	cold	no	no	yes	fishes
whale	warm	yes	no	yes	mammals
frog	cold	no	no	sometimes	amphibians
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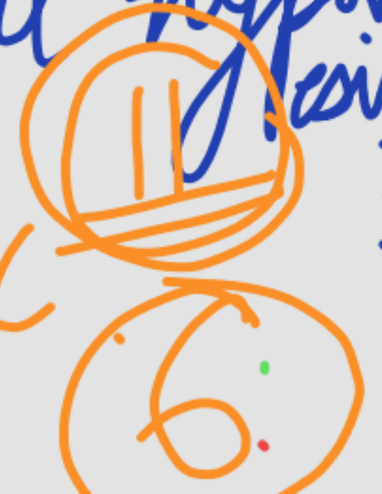
eel	cold	no	no	yes	fishes
salamander	cold	no	no	sometimes	amphibians
gila monster	cold	no	no	no	reptiles
platypus	warm	no	no	no	mammals
owl	warm	no	yes	no	birds
dolphin	warm	yes	no	yes	mammals
eagle	warm	no	yes	no	birds

Which of the following is more general hypothesis?

1. <?, warm, ?, ?, ?, ?> → General

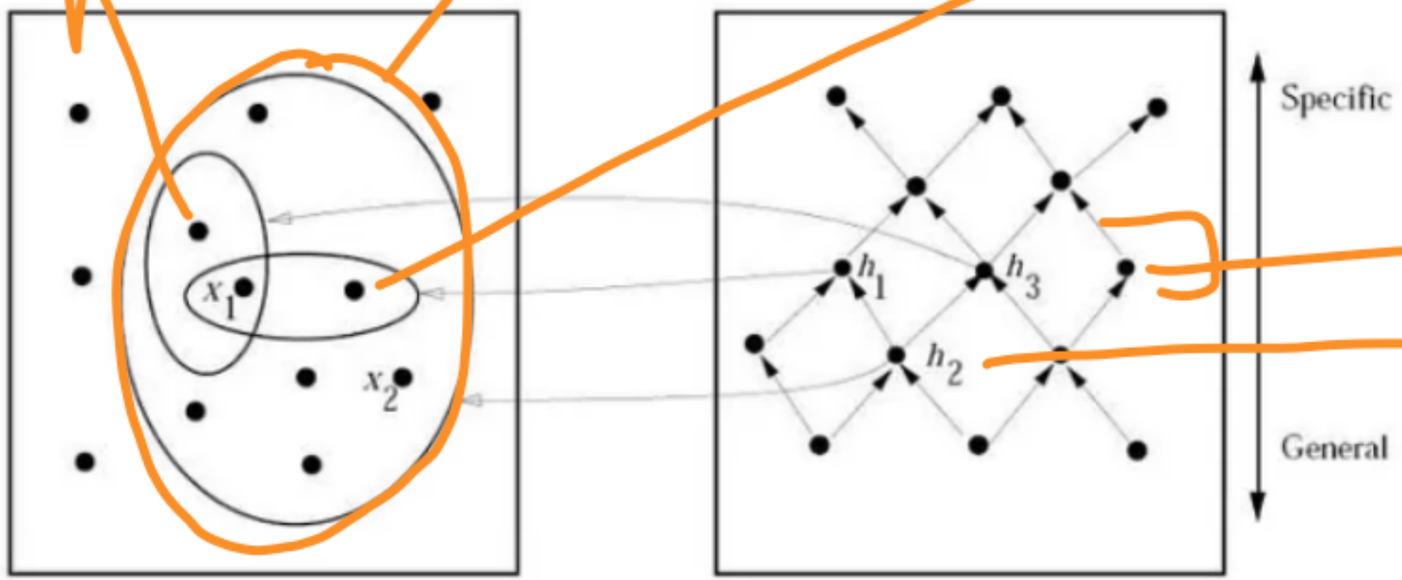
2. <?, warm, yes, ?, ?, ?> → Specific



Definition: Let h_j and h_k be Boolean-valued functions defined over X. Then h_j is **more general-than-or-equal-to** h_k (written $h_j \geq_g h_k$) if and only if

$$(\forall x \in X)[h_k(x) = 1 \rightarrow h_j(x) = 1]$$

The h_j is **more-general-than** h_k ($h_j > h_k$) if and only if $h_j \geq_g h_k$ is true and $h_k \geq_g h_j$ is false. We also say h_k is **more-specific-than** h_j.



x_1 = <Sunny, Warm, High, Strong, Cool, Same>
x_2 = <Sunny, Warm, High, Light, Warm, Same>

h_1 = <Sunny, ?, ?, Strong, ?, ?>
h_2 = <Sunny, ?, ?, ?, ?, ?>
h_3 = <Sunny, ?, ?, ?, Cool, ?>

h2 is more general than h1

h3 is more general to h1

Study of learning algorithms that examine different strategies for searching the hypothesis space, e.g.,

– *Find-S* Algorithm

Example	Sky	AirTemp	Humidity	Wind	Water	Forecast	EnjoySport
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2	Sunny	Warm	High	Strong	Warm	Same	Yes
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4	Sunny	Warm	High	Strong	Cool	Change	Yes

FIND-S: A Simple Learning Algorithm

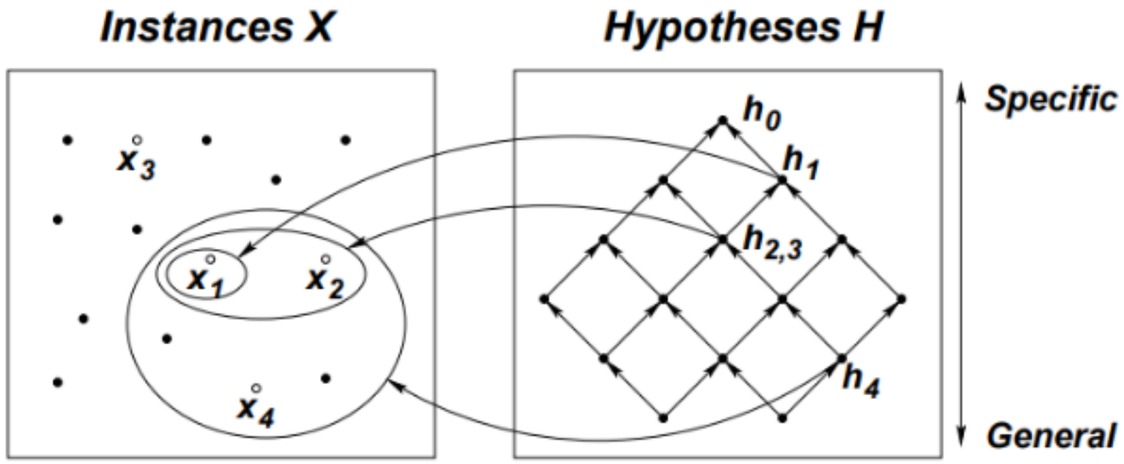
1. Initialize h to the most specific hypothesis in H
2. For each positive training instance x
   - For each attribute constraint a_i in h

     If the constraint a_i in h is satisfied by x

     Then do nothing

     Else replace a_i in h by the next more general constraint that is satisfied by x
3. Output hypothesis h (which is the least specific hypothesis in H, more general than all given positive examples)

Hypothesis Space Search by FIND-S



$x_1 =< Sunny, Warm, Normal, Strong, Warm, Same >, +$

$x_2 =< Sunny, Warm, High, Strong, Warm, Same >, +$

$x_3 =< Rainy, Cold, High, Strong, Warm, Change >, -$

$x_4 =< Sunny, Warm, High, Strong, Cool, Change >, +$

$h_0 =< \emptyset, \emptyset, \emptyset, \emptyset, \emptyset, \emptyset >$

$h_1 =< Sunny, Warm, Normal, Strong, Warm, Same >$

$h_2 =< Sunny, Warm, ?, Strong, Warm, Same >$

$h_3 =< Sunny, Warm, ?, Strong, Warm, Same >$

$h_3 =< Sunny, Warm, ?, Strong, ?, ? >$

Problems ??

1. Are there other consistent hypothesis?
2. Not clear whether we should prefer most general or most specific hypothesis?
3. Are training examples consistent?