Class 3: Sentences in TFL

PHILOSOPHY 201: INTRODUCTION TO LOGIC
WITH ZEE PERRY

First, some admin

Continue to use this website to access the book & syllabi:

- www.zrperry.com/logic201-spring2020

This site will *also* be populated with:

- PDF versions of the slides from previous classes (for review or as a supplemental source when studying)
- Future homework assignments.

This week's HOMEWORK:

Can be turned in via email to:

Zee.Perry@Rutgers.edu

Or, if you have it now, as a hard copy in person.

Review of Previous Class: Arguments

What is a **sentence**, in logic?

Sentences are *full declarative statements*

i.e. they can be true/false

What are **arguments**, in logic?

Arguments are collections of (any number of) sentences

- with ***one*** sentence designated the "**conclusion**"
- and ***all other*** sentences called the "**premises**"

What is **the purpose of an argument**, in logic?

Arguments are supposed to provide *rationally compelling* reason to accept their conclusion.

The premises are supposed to ***support*** the conclusion.

Review of Previous Class: *Deductively Valid* Arguments

The strongest way that an argument's premises can "support" its conclusion is for them to **logically imply** that conclusion. In logic, we call these arguments "**Deductively Valid**" or just "**Valid**".

An argument is valid when its premises are enough to ***guarantee*** the truth of the argument's conclusion, no matter what.

We don't need to *know* whether or not an argument's premises and conclusion are *actually* **true** or **false** to figure out if they're valid!

This argument is valid, even if you didn't just eat expired candy.

1. Every people who eats some of that expired Halloween candy will get sick.
2. You ate some of that expired Halloween candy.
3. You will get sick.

Valid arguments hold in “every case”

If an argument is **Valid**, its premises imply its conclusion no matter what.

- You can dream up any scenario you want, and, so long as the premises are true in the scenario, then the conclusion *must* be true (assuming the argument is valid)

Invalid arguments have Counterexamples.

- Counterexamples are: “cases” that show the argument is bad/invalid.
- Where a “case” is a possible hypothetical scenario (*waves hands*)

Review of Previous Class:
Logical Consequence

A sentence, call it "C", is a **logical consequence** of a list of other sentences, call them "P_1", "P_2", "P_3" (and so on until "P_n"), if and only if there is **no case** where P_1, P_2, …. , P_n are all true and C is not true.

An argument is **Valid** if its conclusion is a **logical consequence** of its premises.

C	is a **(logical) consequence** of	P_1, P_2, …. , and P_n
C	**follows from**	P_1, P_2, …. , and P_n
P_1, P_2,… and P_n	**entail**	C

Truth-Functional Logic (TFL)

This formal language is named ***Truth-Functional Logic***, or, as it's sometimes called, ***Sentential Logic*** (aka the logic of *sentences*).

Every sentence in this language is made using these building blocks:

- **Sentence-Letters**, which stand-in for "atomic sentences"
  (like A, B, Q, X, etc.)
- **Sentential Connectives**, which connect to one or more existing sentence(s) to build a new, more complex sentence!
  (*like* **not**, **and**, **or**, **if.. then..**, *and* **if-and-only-if**)

- We'll use symbols to refer to *these* things too, like ¬ ∧, →, and ↔

Review of previous class: Validity (often) cares only about *Form*

Often, what makes an argument **valid** is something about how the parts of the argument are *structured*, and not on its content.

1. If ____[sentence 1]____, then ____[sentence 2]____.
2. ____[same 1]____.
3. So, ____[sentence 2]____.

Brief Aside: Natural and Formal Languages

Natural Language is a language that is produced naturally, by whatever processes produce the usual languages, dialects, and vocabularies in human societies/communities.

- Natural Language sentences have a logical form, but these forms are usually complicated, and can involve many different grammatical forms, differing aspects and tones, or other linguistic wrinkles.

In logic, we want to understand **logical consequence** in a way that's *systematic* and *general*, which is really difficult if we're working with a natural language.

- To make our job easier, we construct a **Formal Language** that (while limited in what it can express) is much *simpler in form* and always behaves the same way.

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Often, what makes an argument **valid** is something about how the parts of the argument are *structured*, and not on its content.

1. If ___[sentence 1]___, then ___[sentence 2]___.
2. ___[same 1]___.
3. So, ___[sentence 2]___.

Let's simplify by symbolizing!

Any argument with the following *form* will be valid, but we need a less complicated and less unclear way to **describe that form.**

1. If _____A_____, then ____________B____________.
2. _____A_____.
3. So, ____________B____________.

Let's introduce a ***Formal Language*** to let us express what all these arguments have *in common* (by ignoring what makes them different)

We'll use **Italicized Capital Letters** to stand-in for **Sentences**.

- The *same letter* will always refer to the *same sentence* (in any given argument)

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- **Sentence-Letters**, which stand-in for "atomic sentences"
  (represented with **italicized capital letters**, i.e.:
  A, B, Q, X, etc., … you know what letters are)
- **Sentential Connectives**, which connect to one or more existing sentence(s) to build a new, more complex sentence!
  (*like* **not**, **and**, **or**, **if.. then..**, *and* **if-and-only-if**)
- We'll use symbols to refer to *these* things too, like $\neg$ $\wedge$ $\vee$ $\rightarrow$,and $\leftrightarrow$

Truth-Functional Logic (TFL)

	Sentence Component	Representation in English (a popular Natural Language)	Representation in TFL
SENTENCES			
SENTENTIAL CONNECTIVES			

Truth-Functional Logic (TFL)

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SENTENTIAL CONNECTIVES			

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SENTENTIAL CONNECTIVES	Negation		

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	Conjunction		

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	Conjunction	".. and..", ".. but..", ".. however .."	$\wedge$ (Alternatively, '&', '.')
	Disjunction		

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	Disjunction	“Either… or..”, “.. or..”,	$\vee$

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	Material Conditional		

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	Material Conditional	"if.. then.." , ".. only if .."	$\rightarrow$ (Alternatively, '$\supset$')

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	Conjunction	".. and..", ".. but..", ".. however .."	$\wedge$ (Alternatively, '&', '$\cdot$')
	Disjunction	"Either… or..", ".. or..",	$\vee$
	Material Conditional	"if.. then.." , ".. only if .." (or ".. if ..", but only in reverse!)	$\rightarrow$ (Alternatively, '$\supset$')

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	Disjunction	"Either… or..", ".. or..",	$\vee$
	Material Conditional	"if.. then.." , ".. only if .." (or ".. if ..", but only in reverse!)	$\rightarrow$ (Alternatively, '$\supset$')
	Bi-Conditional		

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	Disjunction	"Either… or..", ".. or..",	$\vee$
	Material Conditional	"if.. then..", ".. only if .." (or ".. if ..", but only in reverse!)	$\rightarrow$ (Alternatively, '$\supset$')
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	Material Conditional	"if.. then.." , ".. only if .." (or ".. if ..", but only in reverse!)	$\longrightarrow$ (Alternatively, '⊃')
	Bi-Conditional	".. if and only if..", ".. iff..", "… just in case..",	$\leftrightarrow$ (Alternatively, '≡')

Sentential Connectives: the Material Conditional

The next connective we'll consider is the **material conditional**, represented as '$\rightarrow$'.

'$\rightarrow$' is a ***two-place* connective.** If we consider the sentence "$A \rightarrow B$", then 'A' is the "**antecedent**", and `B' is the "**consequent**" of this **conditional.**

Consider the following conditional:

"Zee drops the chalk $\rightarrow$ The chalk breaks" or "D$\rightarrow$C"

This is TFL for the following natural language conditionals:

If Zee drops the chalk then The chalk breaks

Zee drops the chalk only if The chalk breaks

The chalk breaks if Zee drops the chalk

If ANTECEDENT, then CONSEQUENT

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If ______ANTECEDENT______, then ______CONSEQUENT______

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If ____ANTECEDENT____, then ____CONSEQUENT____

the Material Conditional is a Truth-Function:

Just like all other connectives, the conditional, '$\rightarrow$' doesn't care about what's *inside* the sentences it connects. Rather, it only cares about the truth or falsity of the sentence, in the following way:

Connecting two sentences with '$\rightarrow$' makes a new sentence saying:

- "**If** the antecedent is *true*, **then** the consequent is *true*"
- or, "**Either** the antecedent is *false*, **or** *both* the antecedent and consequent are *true*"

Consider these conditionals, with antecedent "P" and consequent "Q"

"$P \rightarrow Q$" P = "Today is Monday" Q = "Zee is holding chalk"

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"$P \rightarrow Q$"	P = "Today is Monday" Q = "Zee is holding chalk"
"$P \rightarrow Q$"	P = "Zee is holding a kitten" Q = "Rutgers is in Canada"

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Quizlet Q1: Determine if they're **true** or **false**:

"$P \rightarrow Q$" P = "Today is Monday" Q = "Zee is holding chalk"

"$P \rightarrow Q$" P = "Zee is holding a kitten" Q = "Rutgers is in Canada"

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Quizlet Q1: Determine if they're **true** or **false**:

"$P \rightarrow Q$" **TRUE** P = "Today is Monday" Q = "Zee is holding chalk"

"$P \rightarrow Q$" P = "Zee is holding a kitten" Q = "Rutgers is in Canada"

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"$P \rightarrow Q$" **TRUE** P = "Today is Monday" Q = "Zee is holding chalk"

"$P \rightarrow Q$" **TRUE** P = "Zee is holding a kitten" Q = "Rutgers is in Canada"

Sentential Connectives: the Material Bi-conditional

The next connective we'll consider is the **material biconditional**, represented as '$\leftrightarrow$'. It's, as you'd expect, a double-sided conditional

'$\leftrightarrow$' is a ***two-place*** **connective.** If we consider the sentence "$A \leftrightarrow B$", then we say "A iff B". Consider the following conditional:

"Zee drops the chalk $\leftrightarrow$ The chalk falls" or "D $\leftrightarrow$ C"

This is TFL for the following natural language biconditionals:

Zee drops the chalk **if and only if** The chalk falls

Zee drops the chalk **whenever** The chalk falls

The chalk falls **if and only if** Zee drops the chalk

Sentential Connectives: the Material Bi-conditional

The next connective we'll consider is the **material biconditional**, represented as '$\leftrightarrow$ '. It's, as you'd expect, a double-sided conditional

'$\leftrightarrow$ ' is a ***two-place* connective.** If we consider the sentence "$A \leftrightarrow B$", then we say "A iff B".

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the Material Biconditional is a Truth-Function:

Just like all other connectives, the conditional, ‘ $\leftrightarrow$ ’ doesn’t care about what’s *inside* the sentences it connects. Rather, it only cares about the truth or falsity of the sentence, in the following way:

Connecting two sentences with ‘$\leftrightarrow$’ makes a new sentence saying:

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Consider these biconditionals, connecting sentences “P” and “Q”

“$P \leftrightarrow Q$” P = “Today is Tuesday” Q = “Zee has never held chalk”

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Quizlet Q2: Determine if they're **true** or **false**:

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Quizlet Q2: Determine if they’re **true** or **false**:

“$P \leftrightarrow Q$” **TRUE** P =“Today is Tuesday” Q = “Zee has never held chalk”

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Quizlet Q2: Determine if they’re **true** or **false**:

“$P \leftrightarrow Q$” **TRUE** P =“Today is Tuesday” Q = “Zee has never held chalk”

“$P \leftrightarrow Q$” **FALSE** P =“Zee is holding a kitten” Q = “Rutgers is in New Jersey”

Sentential Connectives: Not

“Not” or “¬” is a sentential **connective** because it connects to a sentence and makes a new sentence (the original’s “negation”).

Quizlet Q2: What would be the **negation** of this sentence?

Sentence: It was raining this morning.

Negation: **It’s not the case that** it was raining this morning

It was **not** raining this morning

It isn’t true that it was raining this morning

How would you **translate** the original sentence and its negation into TFL?

Sentence (TFL): It was raining this morning.

Negation (TFL): **It’s not the case that** it was raining this morning.

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How would you **translate** the original sentence and its negation into TFL?

Sentence (TFL): R

Negation (TFL): $\neg R$

Negations are Truth-Functions

The connective "not" or '¬' doesn't care about what's going on *inside* of a sentence or sentence-letter. It just is used to say the *opposite*, or *negation*, of whatever the original sentence says.

So, for **any** sentence, S, you can make its negation: $\neg S$

If "S," is a true statement, then we know that "$\neg S$," must be false. So putting a '¬' in front of any sentence will *switch* it from true to false or from false to true.

Recall: The negation says **ONLY** that the sentence is false:

"Zee is happy"	"Zee isn't happy"	"Zee is unhappy"
H	$\neg H$	U

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Recall: The negation says **ONLY** that the sentence is false:

"**The chair** is happy"	"**The chair** isn't happy"	"**The chair** is unhappy"
H	$\neg H$	U

Sentential Connectives: And

The next connective we'll consider is "and", represented as '$\wedge$'.

'$\wedge$' is a ***two-place* connective** meaning that it links *two* sentences together to make a bigger sentence, the "**conjunction**" of the two.

Consider these two sentences:

"I'm feeling kind of queasy"   "There's still a mile left in this marathon"

and their **conjunction:**

I'm feeling kind of queasy, **and** there's still a mile left in this marathon
I'm feeling kind of queasy, **but** there's still a mile left in this marathon
I'm feeling kind of queasy; **however**, there's still a mile left in this marathon

Sentences in TFL: Q, M Their Conjunction (in TFL): $Q \wedge M$

Sentences as Truth-Functions:

Again, the connective `∧' doesn't care about what's *inside* the sentences. It's just making a new sentence that says "Yeah, whatever *both* these sentences says is true!"

So whenever "P" and "Q" are **both true**, then "$P \wedge Q$" is true.

But if one or both of them is **false**! Then "$P \wedge Q$" will also be false.

So, when would "I'm hungry ∧ There's no food in this room" be true?
When would it be false?

Sentential Connectives: Or

The next connective we'll consider is "or", represented as '∨'.

'∨' is a ***two-place* connective** meaning that it links *two* sentences together to make a bigger sentence, the "**disjunction**" of the two.

Consider these two sentences:

"I'm afraid of geese" "I really can't stand goose honk sounds"

and their **disjunction:**

I'm afraid of geese, **or** I really can't stand goose honk sounds

either I'm afraid of geese, **or** I really can't stand goose honk sounds

I'm afraid of geese, **and/or** I really can't stand goose honk sounds

Sentences in TFL: G, H Their Disjunction (in TFL): $G \vee H$

Sentences as Truth-Functions:

The connective `V' doesn't act quite like you'd expect, given the way that "or" works in natural language.

In logic, the connective 'V' takes two sentences and makes a new one that says "Either *one* or *both* of these sentences is true!". It's what logicians call an "inclusive-'or'

It's like if somebody asked "do you want onions or peppers on your pizza?" and ***you wanted both***, you wouldn't say "Nope!", you'd say "Yes please!".

So whenever either "P", or "Q", or *both* are **true**, then "$P \vee Q$" is true.

But if they're both **false**, then "$P \vee Q$" will also be false.

Sentences have Truth-Values

P
P

Sentences have Truth-Values

P
P
True

There are only TWO Truth-Values

P
p
True
False

There are only TWO Truth-Values

P
P
T
F

Negation “flips” Truth-Value

$(\neg Q)$	
$\neg Q$	Q

Negation "flips" Truth-Value

$(\neg Q)$	
$\neg Q$	Q
	T

Negation "flips" Truth-Value

$(\neg Q)$	
$\neg Q$	Q
F	**T**

Negation “flips” Truth-Value

$(\neg Q)$	
$\neg Q$	Q
F	T
	F

Negation “flips” Truth-Value

$(\neg Q)$	
$\neg Q$	Q
F	T
T	F

Aside: Remember "cases"?

When talking about validity and logical consequence, we talked a lot about "cases", which were something kinda like "possible, hypothetical scenarios".

Now that we're in TFL, the language is simple enough that we can make the concept of a "case" perfectly precise!

A case is **any** distribution of truth-values to each of the ***atomic sentences.***
(in whatever argument/sentence you're considering)

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Now that we're in TFL, the language is simple enough that we can make the concept of a "case" perfectly precise!

- A case (in TFL) is **any** distribution of truth-values to **each** of the ***atomic sentences*** (in whatever argument/sentence you're considering)

Negation "flips" Truth-Value

$(\neg Q)$	
$\neg Q$	Q
F	T
T	F

Negation “flips” Truth-Value

	$(\neg Q)$	
Two possible cases:	$\neg Q$	Q
Q is true	F	T
Q is false	T	F

Always start with the Atomic Sentences

$(A \wedge B)$		
A	$A \wedge B$	B

Always start with the Atomic Sentences

$(A \wedge B)$		
A	$A \wedge B$	B
T		
F		

What are all the possible truth-values for “A” and “B”?

$(A \wedge B)$		
A	$A \wedge B$	B
T		?
F		?

What are all the possible truth-values for "A" and "B"?

$(A \wedge B)$		
A	$A \wedge B$	B
T		?
F		?
?		?
?		?

What are all the possible truth-values for "A" and "B"?

$(A \wedge B)$		
A	$A \wedge B$	B
T		
F		

What are all the possible truth-values for "A" and "B"?

$(A \land B)$		
A	$A \land B$	B
T		T
F		

What are ALL the possible truth-values for "A" and "B"?

$(A \wedge B)$		
A	$A \wedge B$	B
T		T
F		

What are ALL the possible truth-values for "A" and "B"?

$(A \land B)$		
A	$A \land B$	B
T		T
F		
T		F

What are ALL the possible truth-values for “A” and “B”?

$(A \land B)$		
A	$A \land B$	B
T		T
F		T
T		F

What are ALL the possible truth-values for "A" and "B"?

$(A \wedge B)$		
A	$A \wedge B$	B
T		T
F		T
T		F
F		F

What are ALL the possible truth-values for "A" and "B"?

Four possible cases:

	$(A \wedge B)$		
	A	$A \wedge B$	B
Both A and B are true	T		T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F		F

What are ALL the possible truth-values for "A" and "B"?

$(A \land B)$		
A	$A \land B$	B
T		T
F		T
T		F
F		F

Four possible cases:

Both A and B are true

B is true but A is false

A is true but B is false

Both A and B are false

Quizlet Q3:

In which "cases" is:
"$(A \land B)$"
a **TRUE** sentence?

What are ALL the possible truth-values for "A" and "B"?

Four possible cases:

	($A \wedge B$)		
	A	$A \wedge B$	B
Both A and B are true	T		T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F	F	F

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	A	$A \wedge B$	B
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B is true but A is false	F	F	T
A is true but B is false	T	F	F
Both A and B are false	F	F	F

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What are ALL the possible truth-values for “A” and “B”?

Four possible cases:

	($A \wedge B$)		
	A	$A \wedge B$	B
Both A and B are true	T	T	T
B is true but A is false	F	F	T
A is true but B is false	T	F	F
Both A and B are false	F	F	F

Quizlet Q3:

In which “cases” is: “($A \wedge B$)” a **TRUE** sentence?

$(A \vee B)$		
A	$A \vee B$	B

$(A \vee B)$		
A	$A \vee B$	B
T		
F		

$(A \vee B)$		
A	$A \vee B$	B
T		T
F		T

$(A \vee B)$		
A	$A \vee B$	B
T		T
F		T
T		F
F		F

$(A \vee B)$		
A	$A \vee B$	B
T	T	T
F	T	T
T	T	F
F	F	F

Four possible cases:

Both A and B are true

B is true but A is false

A is true but B is false

Both A and B are false

$(A \to B)$		
A	$A \to B$	B

$(A \to B)$		
A	$A \to B$	B
T		
F		

$(A \to B)$		
A	$A \to B$	B
T		T
F		T

$(A \to B)$		
A	$A \to B$	B
T		T
F		T
T		F
F		F

$$(A \rightarrow B)$$

Four possible cases:	A	$A \rightarrow B$	B
Both A and B are true	T		T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F		F

Four possible cases:

Case	A	$A \rightarrow B$	B
	$(A \rightarrow B)$		
Both A and B are true	T		T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F		F

Quizlet Q4:

In which "cases" is: "$(A \rightarrow B)$" a **TRUE** sentence?

Four possible cases:

$(A \rightarrow B)$			
	A	$A \rightarrow B$	B
Both A and B are true	T	T	T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F		F

$(A \rightarrow B)$		
A	$A \rightarrow B$	B
T	T	T
F		T
T	F	F
F		F

Four possible cases:

Both A and B are true

B is true but A is false

A is true but B is false

Both A and B are false

$(A \rightarrow B)$			
Four possible cases:	A	$A \rightarrow B$	B
Both A and B are true	T	T	T
B is true but A is false	F	T	T
A is true but B is false	T	F	F
Both A and B are false	F	T	F

$(A \leftrightarrow B)$		
A	$A \leftrightarrow B$	B

$$(A \leftrightarrow B)$$

A	$A \leftrightarrow B$	B
T		
F		

$(A \leftrightarrow B)$		
A	$A \leftrightarrow B$	B
T		T
F		T
T		F
F		F

$$(A \leftrightarrow B)$$

Four possible cases:

	A	$A \leftrightarrow B$	B
Both A and B are true	T		T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F		F

$$(A \leftrightarrow B)$$

Four possible cases:

	A	$A \leftrightarrow B$	B
Both A and B are true	T	T	T
B is true but A is false	F		T
A is true but B is false	T		F
Both A and B are false	F	T	F

$(A \leftrightarrow B)$			
Four possible cases:	A	$A \leftrightarrow B$	B
Both A and B are true	T	T	T
B is true but A is false	F	F	T
A is true but B is false	T	F	F
Both A and B are false	F	T	F