Exercises to *3.2 Variables and quantifiers*

(1) *For each of the following formulas, specify:*
- *the scope of each quantifier*
- *which variable occurrences are bound and which are free*
- *whether it symbolizes an open sentence or a statement*

1) $\exists x(Fxy \wedge Gx)$

2) $\exists xFxy \wedge Gx$

3) $\exists x\forall yFxy \wedge Gx$

4) $\exists x(Fxy \wedge \forall yGyx)$

5) $\exists xFxx \vee \neg Gx$

6) $\forall y\neg\exists xFxy$

7) $\neg\forall x(\exists yFxy \wedge Gx)$

8) $\forall y[\forall xFxy \rightarrow \neg Gy]$

9) $\neg Gx \rightarrow [\neg\forall y(\neg Fxy \vee \exists xGx)\rightarrow Hy]$

10) $\forall y(\exists yFxy \leftrightarrow Gy)$

(2) *Symbolize the following sentences using the given notation.*

1)	All bats are mammals.	F – …is a bat, G – …is a mammal
2)	Nothing is different from itself.	F – …is different from…
3)	Points are not extended.	F – …is a point, G – …is extended
4)	Some metals are liquid.	F – …is metal, G – …is liquid
5)	Everything is finite or infinite.	F – …is finite
6)	Everything is finite or everything is infinite.	(as above)
7)	Some sharks are not predators.	F – …is a shark, G – …is a predator
8)	Everyone who likes Socrates likes Plato.	F – …likes…, a – Socrates, b – Plato, D – the set of all humans
9)	If all humans are sinful, then the Pope is sinful too.	F – …is human, G – …is sinful, a – the Pope
10)	There are insects with 8 legs.	F – …is an insect, G – …has 8 legs
11)	Bob gave something to Alice.	F – …gave…to…, a – Alice, b – Bob
12)	Alice received nothing from Bob.	(as above)
13)	Bob gave Alice a book.	F – …gave… …, G – …is a book, a – Alice, b – Bob
14)	Alice has a new bike.	F – …has…, G – …is new, H – …is a bike, a – Alice
15)	The otter is not suitable for a pet.	F – …is an otter, G – …is suitable for a pet
16)	There are no cats that do not purr.	F – …is a cat, G – …purrs

17) I hate snakes. F – …is a snake, G – …hates…, a – I

18) Only humans laugh. F – …is human, G – …laughs

19) A necessary condition for something to be an animal is to move. F – …is an animal, G – …moves

20) A sufficient but not necessary condition for a number to be even is to be divisible by 8. F – …is even, G – …is divisible by 8, D – the set of all numbers

21) John is not interested in anything but his dogs. F – …is interested in…, G – …is a dog, H – …belongs to…, a – John

22) Alice avoids everything she doesn't like. F – …avoids…, G – …likes…, a – Alice

23) Alice likes everything Bob likes. F – …likes…, a – Alice, b – Bob

24) John cannot outrun everyone in the team. F – …can outrun…, G – …is in…, a – John, b – the team

25) John cannot outrun anyone in the team.   (as above)