Q8. Identify two different assertions that would make the ontology inconsistent.

1.
```
:andreaMarchetti rdf:type :Technologist
:andreaMarchetti rdf:type :Researcher
```

   Technologist and Researcher are disjoint classes and putting the same individual into both generate inconsistency.

2.
```
:andreaMarchetti :isHostedIn :B-65
:andreaMarchetti :isHostedIn :A-16
```

   Violating exact cardinality constraint (in this case on the fact that each employee has exactly one office) generate inconsistency.

Q9. Define the complex role inclusion axiom capturing the fact that if an employee has an office that is contained in a building that is assigned to an institute that is part of a research organisation, then the employee has a contract with that research organisation.

(isHostedIn **o** isOfficeOf **o** isBuildingOf **o** isInstituteOf) → hasContractWith

Q10. Verify and explain whether or not the created ontology (including the complex role inclusion axiom defined in Q9) satisfies the global restrictions on the axioms of an OWL 2 DL ontology.

Le *global restrictions* are satisfied if all the following restriction are satisfied:

1. "Restriction on `owl:topDataProperty`" : it is **satisfied** because the ontology does not include any axiom on `owl:topDataProperty` and because super-properties of `owl:topDataProperty` do not occur in the ontology.

2. "Restrictions on datatypes":
   a. Each datatype occurring in the ontology is contained in the OWL 2 datatype map, so this restriction is **satisfied**.
   b. Datatype definitions are acyclic: also this condition is **satisfied** because no data ranges are defined.

3. Class expressions and axioms of the following types contain only simple object properties: ObjectMinCardinality, ObjectMaxCardinality, ObjectExactCardinality, ObjectHasSelf, FunctionalObjectProperty, InverseFunctionalObjectProperty, IrreflexiveObjectProperty, AsymmetricObjectProperty, and DisjointObjectProperties.

   No kind of composite object properties is used in them: the object properties that they may contain are simple because they do not have any sub-property that is the right-hand side of a complex role inclusion axiom.
   So that the "Restriction on Simple Roles" is **satisfied**.

4. In the ontology there are not cyclic definitions involving object subproperty axioms with property chains. This means that there are not axioms of the type "SubObjectPropertyOf(…)" that depend on each other (*i.e.* are cyclic) in their definition. So the "Restriction on the Property Hierarchy" is **satisfied**.

5. "Restrictions on Anonymous Individuals" are **satisfied** because no anonymous individual occurs in the ontology.

Q11. Write the following queries in SPARQL:

Q11.1. Find all the offices that host at least one technologist and order the results by office ID.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX : <http://www.semanticweb.org/italian-research-organization#>

SELECT ?office_ID ?office

WHERE {
  ?office rdf:type :Office ;
          :hasOfficeID ?office_ID ;
          :hosts ?technologist .
  ?technologist rdf:type :Technologist .
}

ORDER BY ?office_ID
```

Q11.2. Find all the young researchers with ID lower than 15000 who are members of an institute named "ISTI".

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX : <http://www.semanticweb.org/italian-research-organization#>

SELECT ?young_researcher ?employee_ID

WHERE {
  ?young_researcher :hasEmployeeID ?employee_ID ;
                    rdf:type :YoungResearcher ;
                    :isMemberOfInstitute :ISTI .
  FILTER (?employee_ID < "15000"^^xsd:positiveInteger)
}
```

Q11.3. Among all laboratories in the research organisation ordered by name, find only the names of the two laboratories starting from the third result.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX : <http://www.semanticweb.org/italian-research-organization#>

SELECT ?laboratory ?laboratory_name

WHERE {
  ?laboratory rdf:type :Laboratory ;
              :hasLaboratoryName ?laboratory_name .
}
ORDER BY ?laboratory_name
LIMIT 2
OFFSET 3
```

Q11.4. Find all the research groups that have a total number of employees greater than 2.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX : <http://www.semanticweb.org/italian-research-organization#>

SELECT ?research_group (COUNT(?member) AS ?total_members)
WHERE {
  ?research_group rdf:type :ResearchGroup .
  ?member :isMemberOfResearchGroup ?research_group .
}
GROUP BY ?research_group
HAVING (?total_members >2)
```

Q11.5. Find all the buildings, their offices, and optionally their meeting rooms.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX : <http://www.semanticweb.org/italian-research-organization#>

SELECT ?building ?office ?meeting_room
WHERE {
  ?building rdf:type :Building .
  ?office :isOfficeOf ?building .
  OPTIONAL {?meeting_room :isMeetingRoomOf ?building}
}
```

Q12. Suppose that you want to model the fact that a young researcher is a researcher who is not a senior researcher and not a director. What axiom would you use to describe this fact?

```
:YoungResearcher rdf:type owl:Class ;
                 owl:equivalentClass [ owl:intersectionOf ( :Researcher
                                                            [ owl:intersectionOf ( [ rdf:type owl:Class ;
                                                                                     owl:complementOf :Director
                                                                                   ]
                                                                                   [ rdf:type owl:Class ;
                                                                                     owl:complementOf :SeniorResearcher
                                                                                   ]
                                                                                 ) ;
                                                              rdf:type owl:Class
                                                            ]
                                                          ) ;
                                       rdf:type owl:Class
                                     ] ;
                 rdfs:subClassOf :Researcher ;
```

This means that in Protégé I would select the class YoungResearcher, click the "Equivalent To" button and write the following axiom in the Class Expression Editor Box:

```
Researcher and ( (not Director) and (not SeniorResearcher) )
```