Overview of Logic

Most people nowadays think that animals are capable of a degree of reason, but not (on the whole) that they are capable of logic, which seems to require language, and chains of reasoning that rely on a set of stable concepts. These chains exhibit consistent principles that don't depend on the details of subject-matter. If you replace the subject-matter with letters, you reveal the skeleton of our reasoning processes, and logic is the rules of these processes, and the study of those rules. Analytic philosophers see logic as central to philosophy, but critics are not so sure, and fear that it leads to over-simplification of important issues.

Logic began with **Syllogistic** Logic, which dealt with relations between subject and predicate terms in sentences. There was also some ancient interest (among the Stoics) in Sentential or **Propositional** Logic, relating complete sentences together. In the nineteenth century a more mathematical Propositional Logic appeared (using 'not', 'and', 'or., and 'if…then'), and then **Predicate** Calculus was developed (which added variables for objects and predicates, controlled by quantifiers). One version of this just focused on objects, and became **Classical** Logic, which was tailored to suit mathematics. With that secure base, new branches began to appear. **Modal** Logic introduced 'necessarily' and 'possibly' into the logic, to cope with more speculative reasoning. **Set Theory** used the new logic to reason about collections of things, and formal **Mereology** set up systems to handle part-whole relations.

The next phase was to examine logic more broadly, seeing whether each system was 'consistent' (involving no contradictions) and 'complete' (able to prove all of its truths). Classical Logic was interpreted in terms of *True* and *False*, but other systems then need interpretations (a **semantics**), and an account of **truth**. This led to **Model Theory**, which examined large logical structures. The possibility of implementing these logics electronically led to the invention of **computing**, and that in turn became a focus for logical study. There were also rebellions against the Classical standard, leading to **Intuitionist** logic, and other non-classical systems.

The rules of logic centre on the notion of **Logical Consequence**, which dictates what 'follows' from what, and what counts as an acceptable implication. A few core implications are accepted by everybody, such as that if 'a and b' is true, then 'a' is certainly true. The best-known rule is *Modus Ponens*, which says legitimate implications must be accepted. Most systems of logic accept the classical rules (often formulated as introduction and elimination rules), but non-classical systems challenge even quite basic implications. It is when the origin, nature and status of these rules are discussed that big debates begin, and the Philosophy of Logic specialises in this area.

One key issue is whether logic is descriptive or prescriptive. The first logics described how humans reason, identifying patterns in the argument, and listing the ones that people seem to accept. When predicate logic appeared, it was offered as guidance on how we *ought* reason, and psychologists have since shown that our actual reasoning is often flawed. Both approaches took logic to be studying argument, and describing and criticising its patterns. A common view was that logic studied the 'preservation of truth' in argument, but we can also reason well about falsehoods. With the advent of computers, the emphasis shifted to a more detached study of how formal languages and rules work, and logic has gradually become closer to mathematics, rather than to human thought. There is, though, an unshakable interest in why we feel that some implications *have* to be accepted, and why some logics are important and others not.

If logic does aim to display correct reasoning, this invites the big question of whether there is 'one true logic', or at least a true core to logic (to which additions can be made). This will depend on what we take the source of our logic to be, and the three main contending views here are that logic is a set of eternal truth (platonism), that it is a matter of human convention, and that it derives in some way from nature. The first and third of these seem to imply the possibility of a 'correct' logic, whereas the convention view has no room for such an idea. The **platonist** approach rests on the idea that there is a world of ideas that is distinct from the physical world, and that this world of ideas contains a rational order, perhaps controlled by 'pure reason', and that logicians are trying to interpret this order. The view of logic as **convention** connects to the interest in computing and formal languages, and allows the introduction of any rules and axioms that seem interesting. The study will be guided by a preference for languages that have simple foundations, deliver a highly ordered system, and are very fruitful (though such preferences are themselves conventions). An extreme view is that you can adopt any convention you like, or give up your logic if you don't like its results. If logic is derived from **nature**, then there is presumed to be a structure in the physical world (rather than the world of ideas), and logic is an accurate abstract description of what controls that structure. Supporters of the naturalistic approach take an interest in **Quantum Logic**, a revision aimed at fitting new structures found in nature.

Classical Logic is described as 'first-order', because the quantifiers only refer to variables that pick out objects in the domain (to which predicates can be attached). '**Second-order**' logic also quantifies over the predicates themselves (either as entities, or as subsets of the domain of objects). Mathematics needs this second-order logic in order to characterise its activities properly, but at the expense of involving set theory in the logic, or platonist commitments to 'properties', so that critics say it is not really logic, and certainly not 'pure' logic. A recent proposal has been to allow '**plural quantification**', which may have the advantage of quantifying over groups of objects without having to get bogged down in set theory.

Most students of logic believe that it has a '**pure**' form, which is the heart of reasoning. Pure logic must have no ontological commitments, and aims to embody a universal system, into which any subject-matter can be inserted, with the actual formal or natural language being employed having no relevance. Various criteria are employed to assess the merits of a logic. The minimum requirement is that it be 'sound', meaning that only truths can be proved. A logic seems very secure if it is 'complete', meaning that all truths can be proved. Classical logic passes both tests, so that what can be formally proved ($A \vdash B$, read as 'B can be proved from A') is the same as what is 'semantically valid', where $A \models B$ means 'B is always true when A is true'.