under discussion is called the object language, and the language in which the discussion is conducted is called the metalanguage. One might suppose object language and metalanguage could coincide – for example we commonly use English to discuss English – but in 1936 Tarski (*b* 1902) pointed out that in this case it is difficult to avoid the semantic paradoxes, and so was led to insist that the semantic properties and relations (such as 'true', or 'denotes') which hold for the words and sentences of a given language could not be expressed in that language, but only in a different language which was a metalanguage for that language. Pursuing this approach, a natural language such as English is regarded as falling into a hierarchy of different languages. The lowest level contains no semantic vocabulary; for any level, we form the next higher level by *adding* to it the vocabulary needed in order to speak of its expressions and of their semantic properties and relations. The approach is often criticized for its artificiality when applied to natural languages, but it has led to important results in *mathematical logic [*Tarski's theory of truth].

DB

metallurgy. *See* technology.

metamerism. *See* isomerism.

metamorphosis. Classically, metamorphosis referred to sudden changes caused supernaturally. Thus, Ovid's (43 BC – AD 17) *Metamorphoses* recorded transformations by 'heavenly powers' of Chaos into an ordered Universe, and of people into beasts (cf. *witchcraft). By the 17th century, naturalists studied sudden organic changes or transformations seeking to eliminate supernatural causes. In particular, Jan Swammerdam (1637–80) studied insect metamorphosis, identifying successive stages. Later, J. W. von Goethe (1749–1832), especially in his *Metamorphose der Pflanzen* (1790), suggested change was not sudden and stressed the transformation of a basic *archetypal plant (*Urpflanze*) into different parts. Thus he saw the petals, stamens and pistils of a plant as metamorphosed leaves, and the vertebrate skull as a complex of metamorphosed vertebrae [*development; *morphology; **Naturphilosophie*]. Others, e.g. E. Geoffroy St Hilaire (1772–1844), studied the 'metamorphosis' of embryos in normal and *monstrous development. Nowadays, the term is applied only to larvae. The phenomenon is found in *species where juveniles and adults have very different habits [*adaptation; *evolution].

JM

metamorphosis (geology). *See* mineralogy; tectonics; volcanoes; vulcanism.

metaphor in science. Metaphorical redescription (e.g. *light as waves rather than particles) is often held to be central to theoretical changes in science. A new metaphor does not merely provide 'answers' to pre-existing 'questions': rather, by radically recasting our perceptions, it creates new problems, observational terms and *experimental strategies, and hence largely determines the nature of *empirical results. In the 'interaction' view, metaphor can be thought of as effectively *creating* similarities; it suggests possible relations and analogies, many of which are neither clearly 'positive' or 'negative', and hence are open for experimental exploration. If *revolutionary science, when *paradigms are changing, involves radical metaphorical revision, the 'incommensurability' of old and new is explicable. Metaphors drawn from social forms and technologies can be the vehicle for *external influences on scientific knowledge. Analysis of metaphor illuminates such problems as how to talk about unobservables, and the nature of changes in the meaning of theoretical terms.

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metaphysics. A multi-faceted term, originally used to refer to the subject of Aristotle's (384–322 BC) untitled texts dealing with 'first philosophy' (theology or wisdom), interpreted by his early editors as coming 'after the things of Nature', i.e. as arising out of but going beyond purely factual or scientific questions. Hence, it is often used synonymously with (a) philosophy *per se*, including *ontology or theory of being, *epistemology or theory of knowledge and the relations between them or (b) more broadly, any more or less synoptic world-view (e.g. *mechanism). Following the neo-Kantian and *realist critiques of *positivist philosophy of science, it is accepted that any developing scientific research programme depends on one or more metaphysics in a sense related to (b): viz categorial frameworks not directly testable in