Chapter 4
Particle Concept of Matter

The particle concept presents fundamental advantages, but also certain
difficulties to students. The common particle concept of matter associates for
each pure matter a special kind of particle, mostly spheres as models: e.g. one
sphere for one water particle, another kind of sphere for one sugar particle, the
mixture of both kinds of spheres the dissolution of sugar in water. On the other
hand, one can use a generic particle term for atoms, ions and molecules; one can
only ascertain it from the context which particle term is discussed.

In addition, students gain their first insight into the general use of scientific
models through the common particle concept. Unfortunately these scientific
models of matter have almost nothing to do with well-known models of cars or
airplanes, with dolls or soft toys. There are originals for these models which
can be built in miniature according to the subjective interest of the model
builder: modeling a car one builder puts emphasis perhaps on the wheel-
turning ability, the other one on glass windows of the model. For creating
scientific models according to the composition of matter there are no atoms,
ions or molecules to be seen, neither the chemical structure of matter nor
chemical bonding – scientists have created these models according to the
interpretation and reflection of many properties and chemical reactions of
many substances.

Main Attributes of General Model Concepts. After an empirical analysis of
the general model concept, Stachiowiak [2] differentiates between three basic
traits. The Image Trait deals with “models that are always images of something,
therefore representatives of certain natural or artificial origins”. The Shortening
Trait is about “models that do not represent all aspects of the original but only
those which are relevant to the individual creator or user”. The Subjective Trait
means, “models fulfill their representational and substitution usage only for
certain subjects being limited by particular theoretical or real operations”.

Traits of the Scientific Model Concepts. Steinbuch [3] presents a scheme for
indicating the epistemological process in science (see Fig. 4.2): “Any complex
reality issue as the original, is recreated through a particular perception as an
abstract model, a thought model by using only the essentials which are relevant.
For this purpose certain information or generally-acknowledged rules of logic
or physics are added. So we have for our perception a model for future thought
processes. This abstract thought model can be used for projection back to reality by building concrete models. These models contain unavoidable irrelevant attachments which the thought model do not contain” [3].

This “thinking in models” can be relayed for example as in the perception of Max von Laue, who in 1912 confirmed the structural theory of 3-dimensional crystal lattices by using a beam of X-rays [4]. The interference pattern of a sodium chloride crystal, which through interference and diffraction of the X-ray-beam is formed, is the original, and therefore the essential part, passing through the “sieve” (see Figs. 4.2 and 4.3).

Diffraction of light in two-dimensional lattices and their calculations were known in Laue’s time: an additional information. They have been the basis for Laue’s calculation of three-dimensional diffraction lattices from X-ray experiments; as a result he formulated a model of a spatial symmetrical structure of ions in a salt crystal: abstract mental model. Laue proposed the use of realistic models in order to better visualize the concepts – but needed irrelevant items like balls, sticks and glue, in order to construct closest packings of spheres or spatial lattice models: concrete models.

This scientific mode of moving from “left to right” in Steinbach’s scheme is possible for an expert but not for a novice who is just beginning to think in terms of models. Students are much more likely to be led from “right to left” after having been introduced to the phenomenon or to the original. It is necessary initially to have concrete models in order to be able to develop further mental

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Fig. 4.2 Scheme “Thinking in model terms” by Steinbuch [3]