Both of these theories make the following two assumptions:

1. The solid–liquid interface consists of an infinitesimally thin film (h) of saturated solution that is in intimate contact with the solid.
2. The bulk of the solution is assumed to be well mixed and the concentration of the dissolving solid in the bulk at any given time is c_t.

Interfacial Barrier Model

According to this model, the intrinsic dissolution rate (J) is controlled by the surface reaction between the solute and solvent. If this reaction is first-order, then

$$J = \left(\frac{\mathrm{d}m}{\mathrm{d}t}\right)\left(\frac{1}{S}\right) = k_R\left(c_s - c_t\right) \tag{17.9}$$

where k_R is the first-order rate constant for the interfacial reaction and c_s is the concentration of solute at saturation. In this model, transport is not rate-limiting; therefore, the solute concentration gradient ($c_s - c_t$) can be quite large over an infinitesimal distance. For organic substrates, there are not many cases for which the interfacial barrier model applies. The dissolution of gallstones is one example.

Diffusion-Layer Model

One of the earliest theoretical treatments describing dissolution phenomena is attributed to Noyes and Whitney for their investigation of the dissolution of benzoic acid and lead chloride in water (1897). These solutes, because of their low aqueous solubility, were chosen to minimize the change in surface area as the solutes dissolved. As mentioned earlier, it was assumed that an *indefinitely* thin layer of saturated solution was formed instantly around the solute, followed by diffusion of the solute into the bulk solution. Since the first step is fast compared to the second, diffusion into the bulk was taken as the rate-limiting step. The dissolution rate was then modeled using Fick's second law of diffusion and the concentration gradient of the solute. This led to the following first-order equation:

$$\frac{\mathrm{d}c}{\mathrm{d}t} = k\left(c_s - c_t\right) \tag{17.10}$$

where dc/dt refers to the dissolution rate of the substance in terms of concentration, and k is a dissolution constant.

Permutations of Diffusion-Layer Model

In order to extend the range of Equation 17.10 from sparingly soluble to more soluble substances, Brunner and Tolloczko (1900) modified Noyes and Whitney's model to account for the changing surface area with time:

$$\frac{\mathrm{d}c}{\mathrm{d}t} = k_1 S\left(c_s - c_t\right) \tag{17.11}$$

where k_1 is the dissolution rate constant that takes into account the specific surface area. Note that k_1 is equivalent to the transport rate constant, k_T. It was also pointed out that the rate of dissolution depended on the temperature, structure of the crystal surface, rate of stirring, and arrangement of the experimental apparatus.