where n is the number of stages. Figure 11.9 depicts the relationship between E, X_n/X_0, and n, which is used to determine the number of stages (n) required for a certain degree of extraction (X_n/X_0) for a given system (E).

Most antibiotics are extracted from the fermentation broth by using solvents such as amylacetate or isoamylacetate. Usually, continuous *centrifugal Podbielniak extractors* are used for the extraction of antibiotics. Penicillin is more soluble in organic phase at low pHs (pH = 2 to 3) and is highly soluble in aqueous phase at high pHs (pH = 8 to 9). Therefore, penicillin is extracted between organic and aqueous phases several times by shifting the pH to improve the purity of the product. Figure 11.10 depicts the variation of distribution coefficient (solvent–aqueous) with pH in penicillin extraction by amylacetate.

Some products to be recovered from the fermentation broth are weak acids or weak bases. Since compounds that are not ionized are soluble in the organic phase, the pH conditions are selected such that the extracted compound is neutral and is soluble in an organic solvent. Therefore, weak bases are extracted at high pHs and weak acids are extracted at low pH values in the neutral form.

If fermentation broth contains more than one component, then the selectivity (β) of the solvent becomes an important parameter. The selectivity coefficient (β_{ij}) is defined as

$$\beta_{ij} = \frac{K_i}{K_j} \tag{11.35}$$

The ease of separation depends on the β_{ij} value: the higher the β_{ij} value is, the easier the separation of i from j. In some cases, the β_{ij} value changes appreciably with a pH shift and

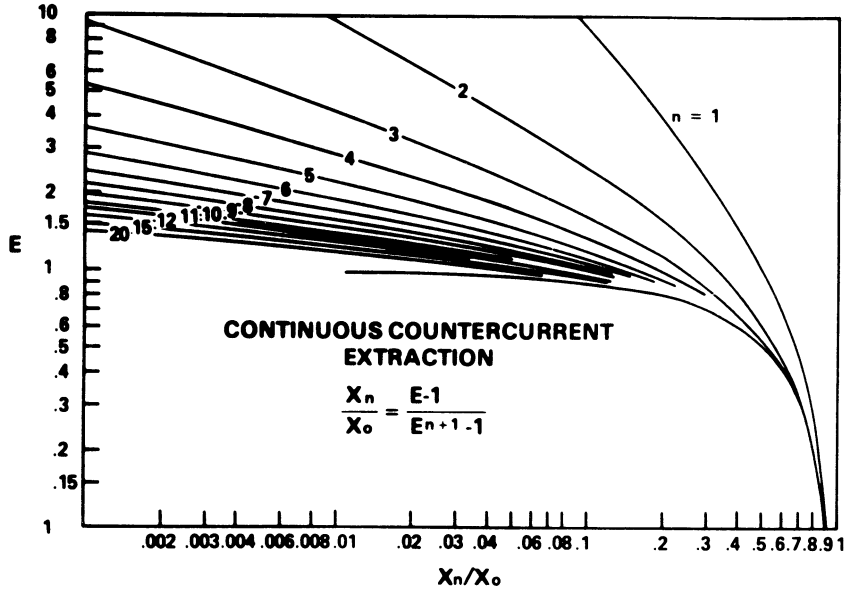

Figure 11.9. Relationship between unextracted solute, extraction factor, and number of stages in continuous countercurrent extraction. (With permission, from L. C. Craig, D. Craig, and E. C. Scheibel in *Technique of Organic Chemistry*, A. Weissberger, ed., 2d ed., Vol. 3, Part 1, Wiley—Interscience, New York, 1956.)