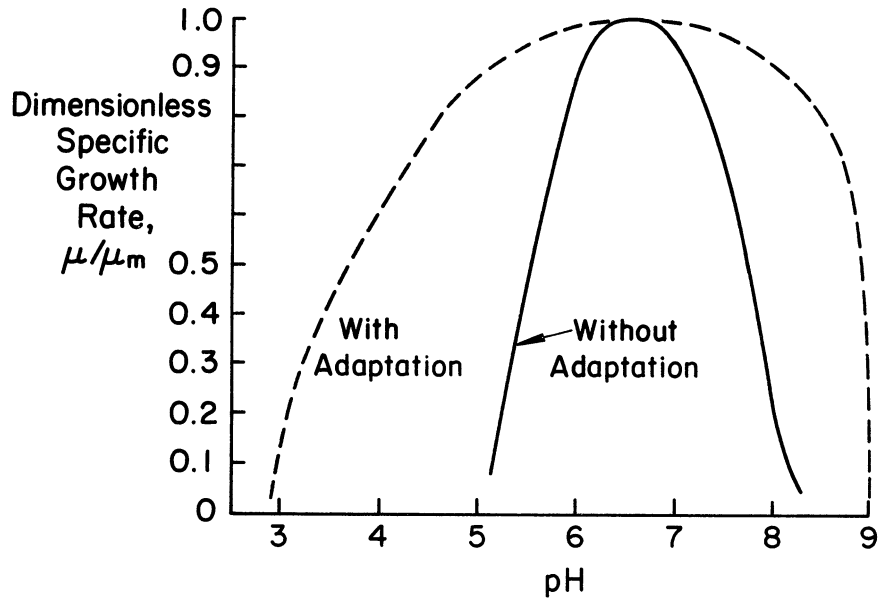

Figure 6.8. Typical variation of specific growth rate with pH. The units are arbitrary. With some microbial cultures, it is possible to adapt cultures to a wider range of pH values if pH changes are made in small increments from culture transfer to transfer.

DO level is below the critical DO concentration. In this case, another medium component (e.g., glucose, ammonium) becomes growth-extent limiting. For example, with *Azotobacter vinelandii* at a DO = 0.05 mg/l, the growth rate is about 50% of maximum even if a large amount of glucose is present. However, the maximum amount of cells formed is not determined by the DO, as oxygen is continually resupplied. If glucose were totally consumed, growth would cease even if DO = 0.05 mg/l. Thus, the extent of growth (mass of cells formed) would depend on glucose, while the growth rate for most of the culture period would depend on the value of DO.

The critical oxygen concentration is about 5% to 10% of the saturated DO concentration for bacteria and yeast and about 10% to 50% of the saturated DO concentration for mold cultures, depending on the pellet size of molds. Saturated DO concentration in water at 25°C and 1 atm pressure is about 7 ppm. The presence of dissolved salts and organics can alter the saturation value, while increasingly high temperatures decrease the saturation value.

Oxygen is usually introduced to fermentation broth by sparging air through the broth. Oxygen transfer from gas bubbles to cells is usually limited by oxygen transfer through the liquid film surrounding the gas bubbles. The rate of oxygen transfer from the gas to liquid phase is given by

$$N_{O_2} = k_L a(C^* - C_L) = \text{OTR} \tag{6.21}$$

where k_L is the oxygen transfer coefficient (cm/h), a is the gas–liquid interfacial area (cm^2/cm^3), k_La is the volumetric oxygen transfer coefficient (h^{-1}), C^* is saturated DO