The Quasi-Steste Approach to enzyme kinetics(Briggs-Haldane)

```
            kf1->  kf2->
          S+E<---->SE---->P+E
            <-kb1     <-kb2
```
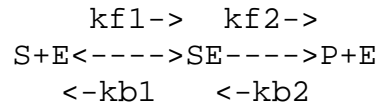
The differential equations for a saturable reversible enzyme conversion process are given as

$$d[S]/dt=-kf1*[S][E]+kb1*[SE]$$

$$d[SE]/dt=+kf1*[S][E]-(kf2+kb1)*[SE]+kb2*[P][E].$$

There are two conservation equations"

$$[S_{TOT}]=[S]+[SE]+[P]$$

$$[E_{TOT}]=[E]+[SE] \ .$$

The usual assumptions given in texts are that kb2=0, and kf1,kb1 >> kf2 so that [SE] and [S] are in equilibrium (Michaelis-Menten) or that [SE] is in a quasi-steady state (Briggs-Haldane). The result in either case is that the rate of change of the substrate enzyme complex, d[SE]/dt, is very small (assumed zero) and we can set

$$kf1*[S]*[E]-(kf2+kb1)*[SE]=0.$$

Solve for [E] to get

$$[E]=(kf2+kb1)*[SE]/(kf1*[S])$$

We can write
$$[E]=((kf2+kb1)/kf1)*[SE]/[S]$$

$$Km=(kf2+kb1)/kf1.$$

Therefore,
$$[E]=Km[SE]/[S].$$

Substitute this expression into the second conservation

equation yielding

$$[E_{TOT}] = Km[SE]/[S] + [SE].$$

Solving this equation for [SE] yields

$$[SE] = [E_{TOT}][S]/(Km + [S]).$$

Substituting the expression for [E] into the equation for d[S]/dt yields

$$d[S]/dt = -kf1*[S][E] + kb1*[SE]$$

$$d[S]/dt = -kf1*[S]*Km*[SE]/[S] + kb1*[SE]$$

to give

$$d[S]/dt = (-kf1*Km + kb1)*[SE] = -kf2*[SE].$$

Substituting for [SE] gives

$$d[S]/dt = -kf2*[E_{TOT}][S]/(Km + [S]).$$

Letting

$$kf2*[E_{TOT}] = Vmax$$

allows us to write the familiar Michaelis-Menten (Briggs-Haldane) form,

$$d[S]/dt = -Vmax[S]/(Km + [S]).$$

   In 1925, G. E. Briggs and J.B.S. Haldane derived a new interpretation of the enzyme kinetics law described by Victor Henri in 1903, different from the 1913 Michaelis-Menten equation. Leonor Michaelis and Maud Menten assumed that enzyme (catalyst) and substrate (reactant) are in fast equilibrium with their complex, which then dissociates to yield product and free enzyme. The Briggs-Haldane equation was of the same algebraic form, but their derivation is based on the quasi steady state approximation, that is the concentration(s) of intermediate complex(es) do(es) not change. As a result, the microscopic meaning of the "Michaelis Constant" (Km) is different. Although commonly referring it as Michaelis-Menten kinetics, most of the current models actually use the Briggs-Haldane derivation.