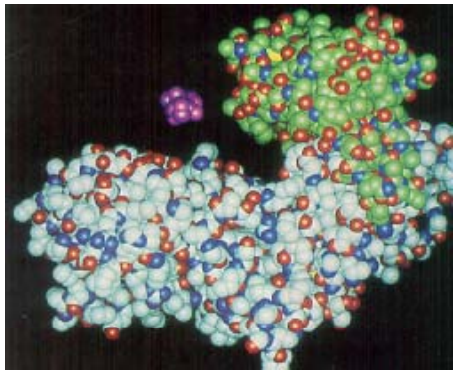
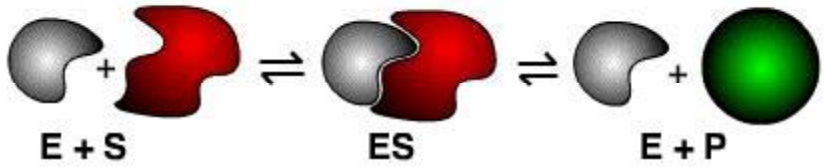
Soil Enzymes



$$E + S \rightleftharpoons ES \rightarrow E + P$$

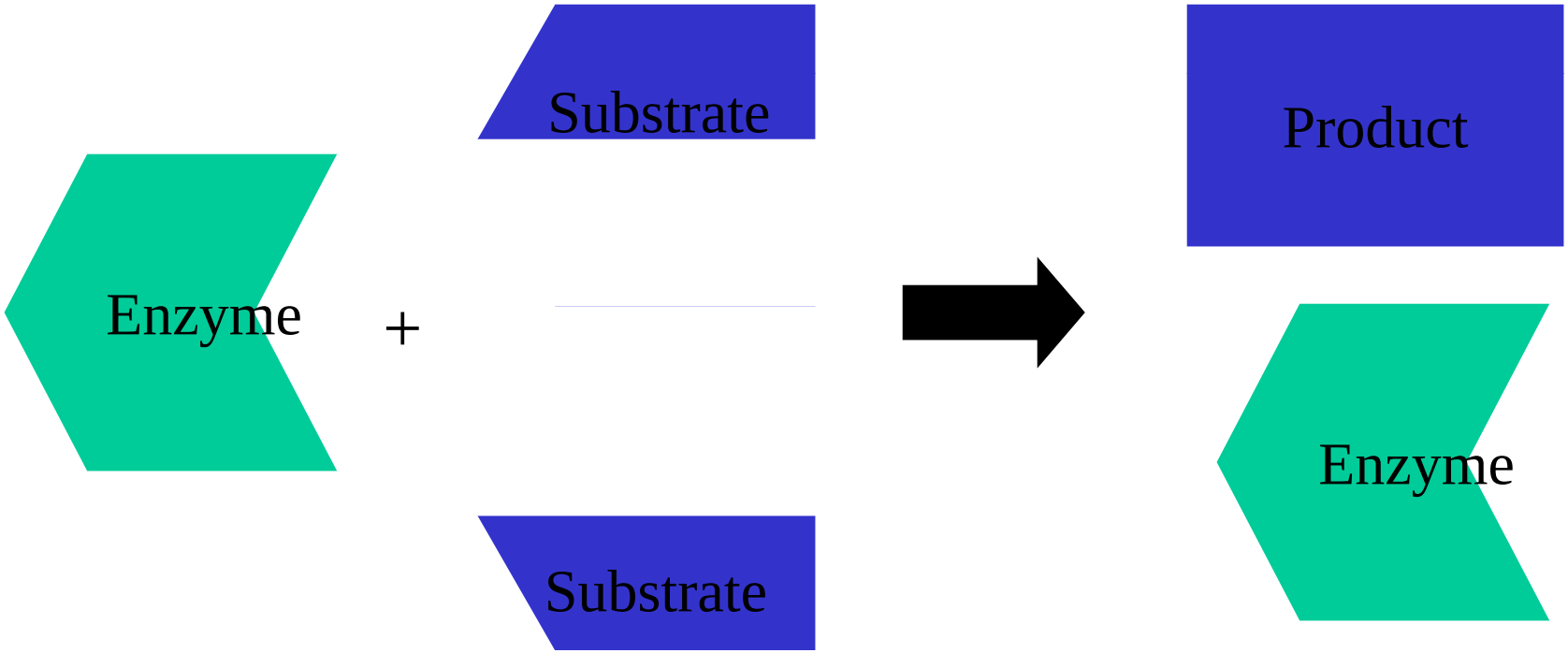
Definition of Enzymes



- Enzyme (E) – A protein produced by a cell to act as a catalyst

- Substrate (S) – A compound acted upon by an enzyme

Enzymes are proteins that allow reactions to proceed at faster rates by reducing the energy of activation of the reaction:



Sources of Enzymes in Soil

- Plants, soil animals, and microorganisms
- Enzymes accumulated in soils are present as:
  - Free enzymes (Exoenzymes)
  - Endoenzymes (cytoplasm, periplasm)

Kiss et al. 1975

Types of Enzymes

- Constitutive enzymes

  Used frequently in the cell – always present

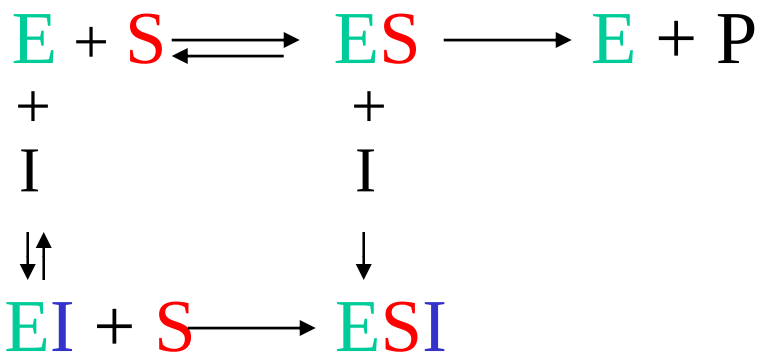
- Inducible enzymes

  In the genetic code – only produced when needed

State of Soil Enzymes

- Enzymes may be destroyed by proteases
- Enzymes may be protected by clay or humus
  - Enzyme-clay and enzyme-organic polymer complexes resistant to denaturation

Soil enzyme assays…



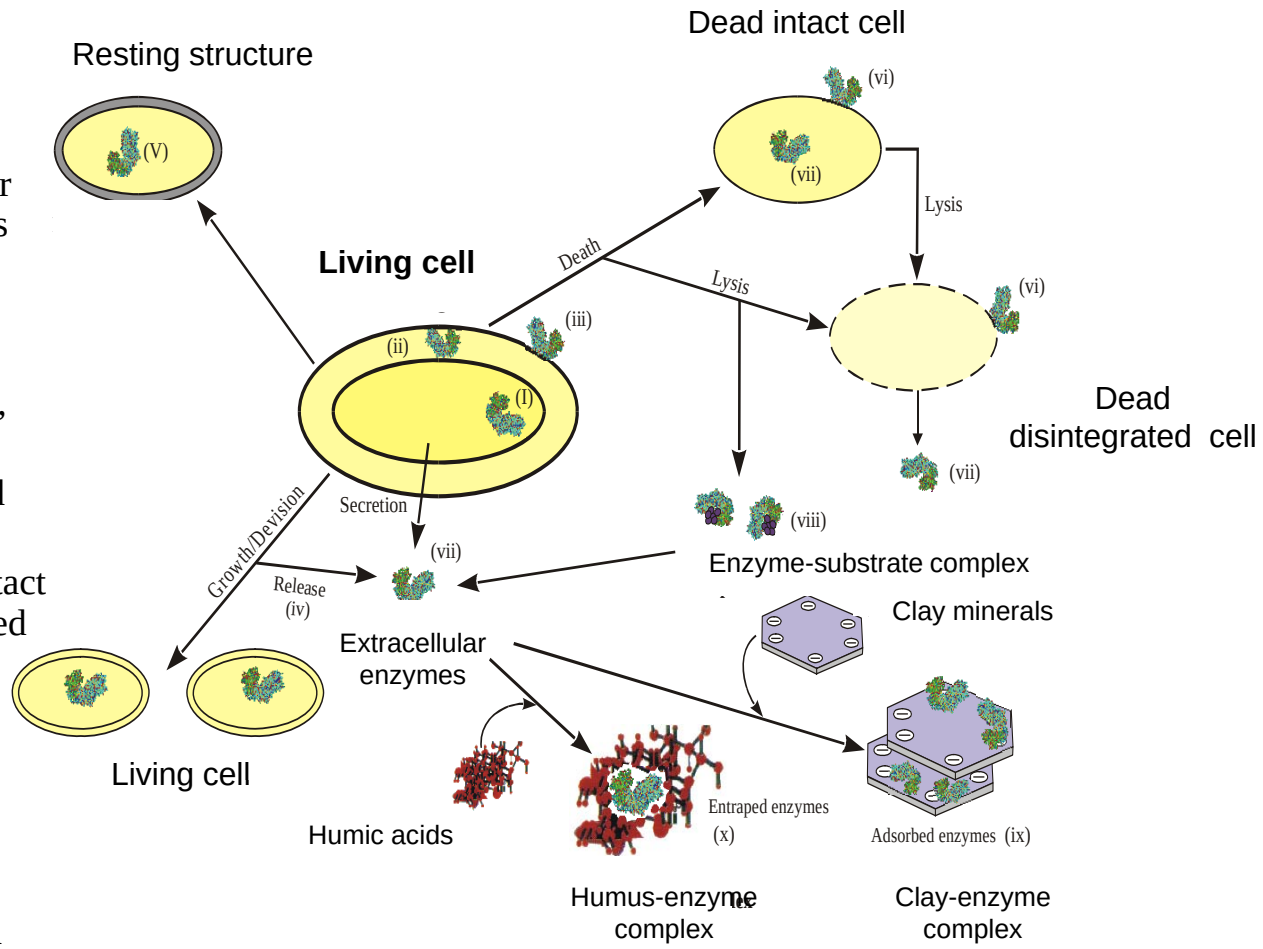
E = Enzyme;
S = Substrate;
I = Inhibitor ;
P= Product.

- **Are based mostly on the quantification of the product (P) released upon adding known amount of substrate (S) to the soil, and allowing the reaction to occur under controlled temperature, pH and ionic strength.**

- **If an inhibitor (I) (i.e., metal) is present in the soil, EI and/or ESI complexes could be formed in addition to the ES (enzyme-substrate) complex normally formed.**

Location of Enzymes in Soils

(i) Intracellular enzymes
(ii) Periplasmatic enzymes
(iii) Enzymes attached to outer surface of cell membranes
(iv) Enzymes released during cell growth and division
(v) Enzymes within non-proliferating cells (spores, cysts, seeds, endospores)
(vi) Enzymes attached to dead cells and cell debris
(vii) Enzymes leaking from intact cells or released from lysed cells
(viii) Enzymes temporarily associated in enzyme-substrate complexes
(ix) Enzymes absorbed to surfaces of clay minerals
(x) Enzymes complexed with humic colloids

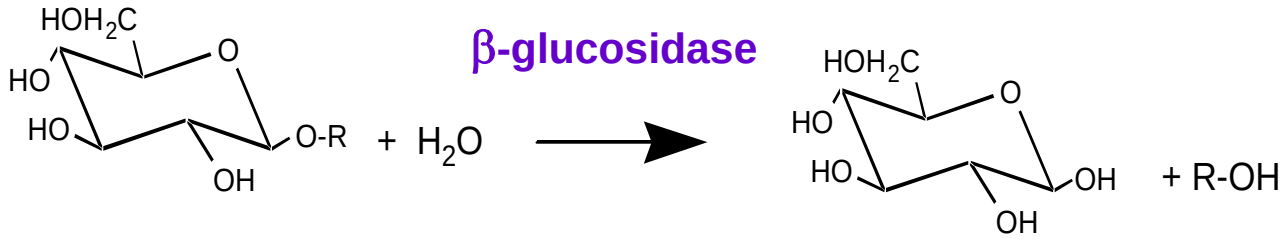


Prepared by my colleague Dr. Klose according to Burns 1982, Nannipieri 1994

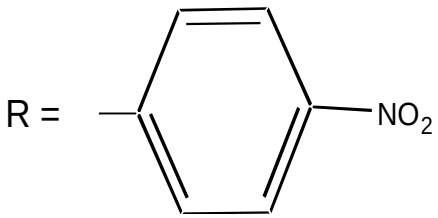
Selected enzyme reactions

- Carbon mineralization:

β-Glucosidase catalyzes the final limiting step of cellulose degradation

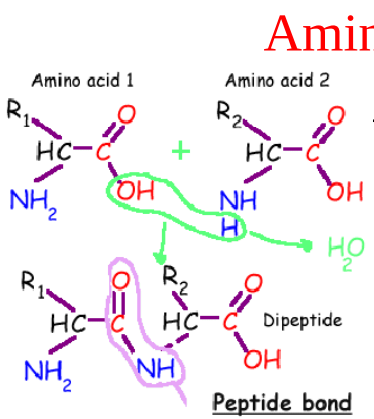


p-nitrophenyl-β-D-glucoside β-glucoside *p*-nitrophenol



Selected enzyme reactions

- Nitrogen mineralization

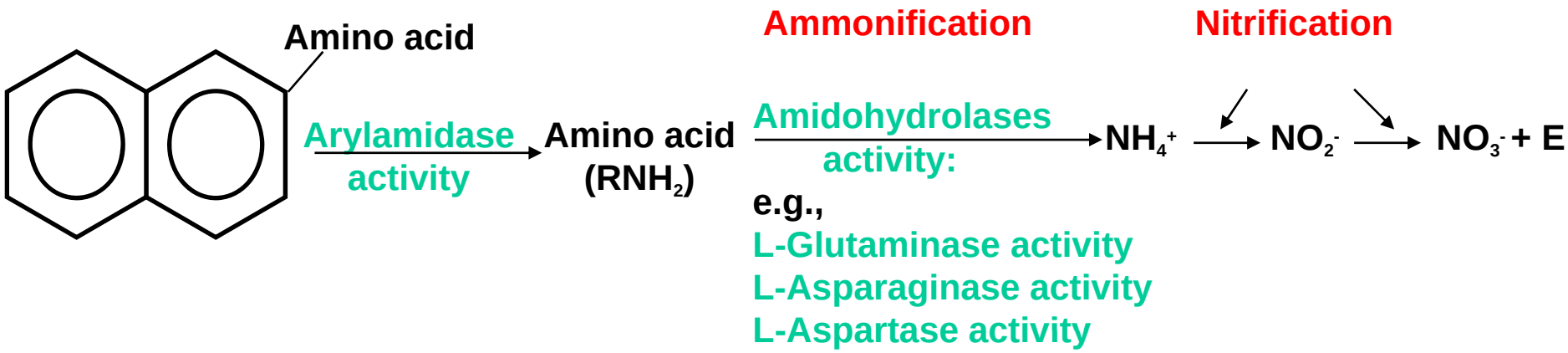


Aminization Ammonification Nitrification

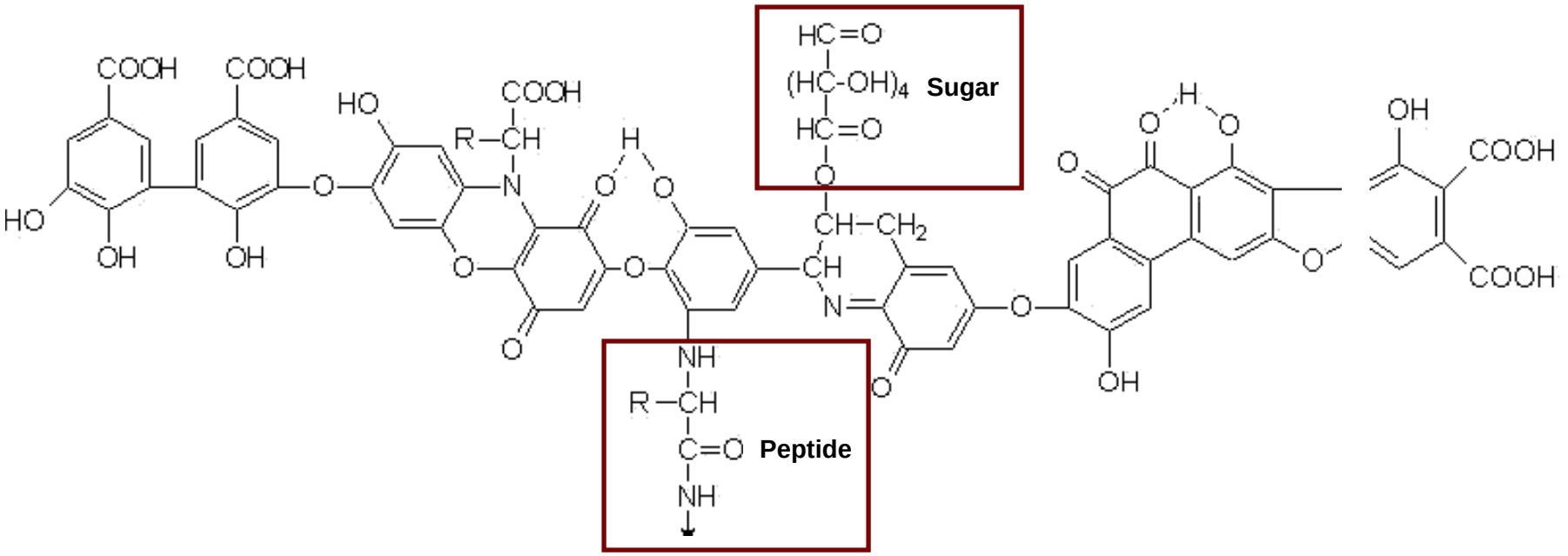
$$\xrightarrow{} RNH_2 \xrightarrow{} NH_4^+ \xrightarrow{} NO_2^- \xrightarrow{} NO_3^- + \text{energy}$$

i.e.=Proteins

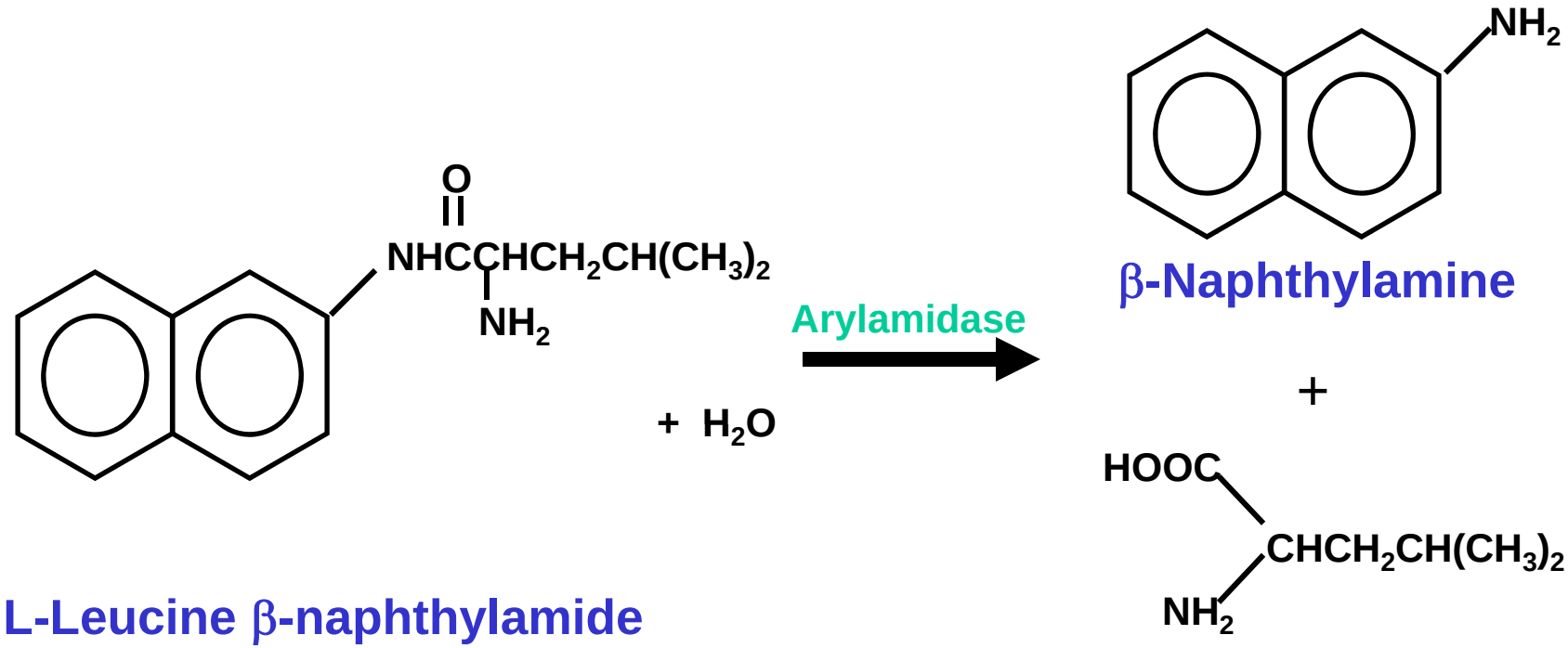
Amino acid mineralization in soils (begins by the release of amino acids from organic matter)



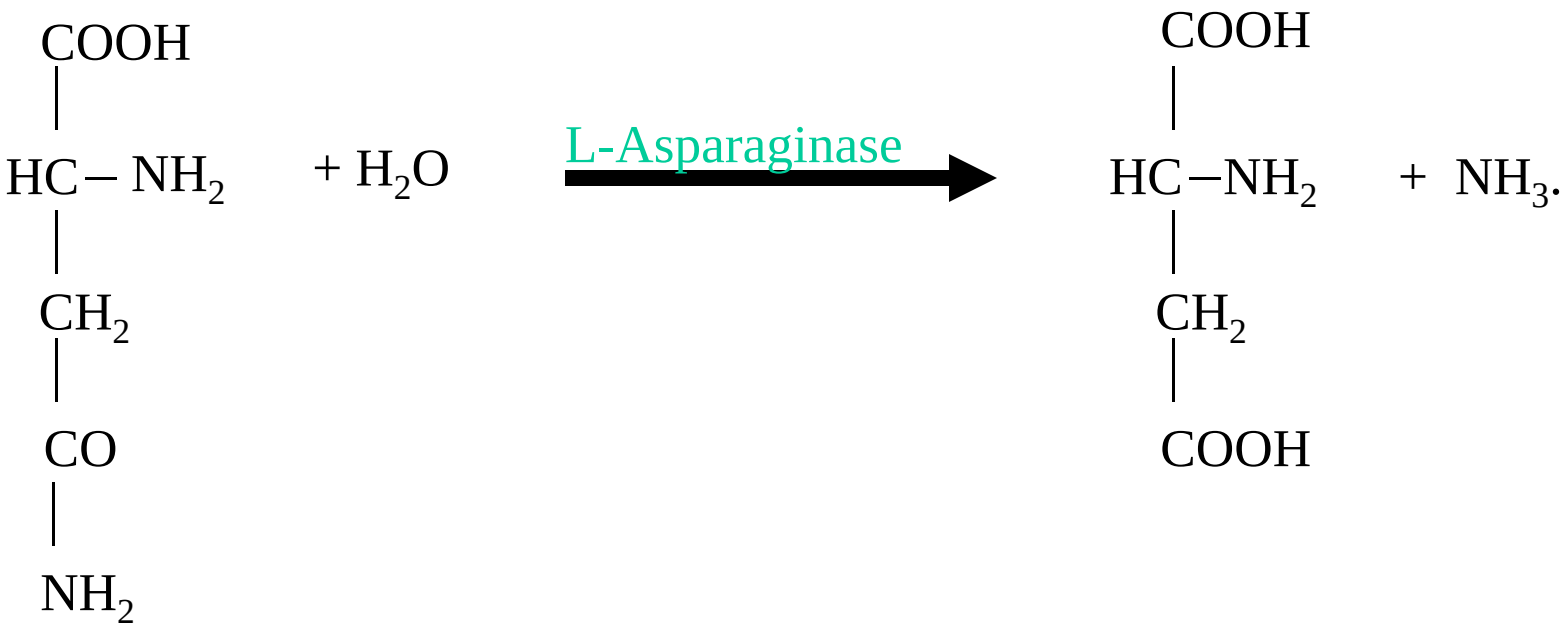
Hypothetical structure of humic acid (Stevenson)



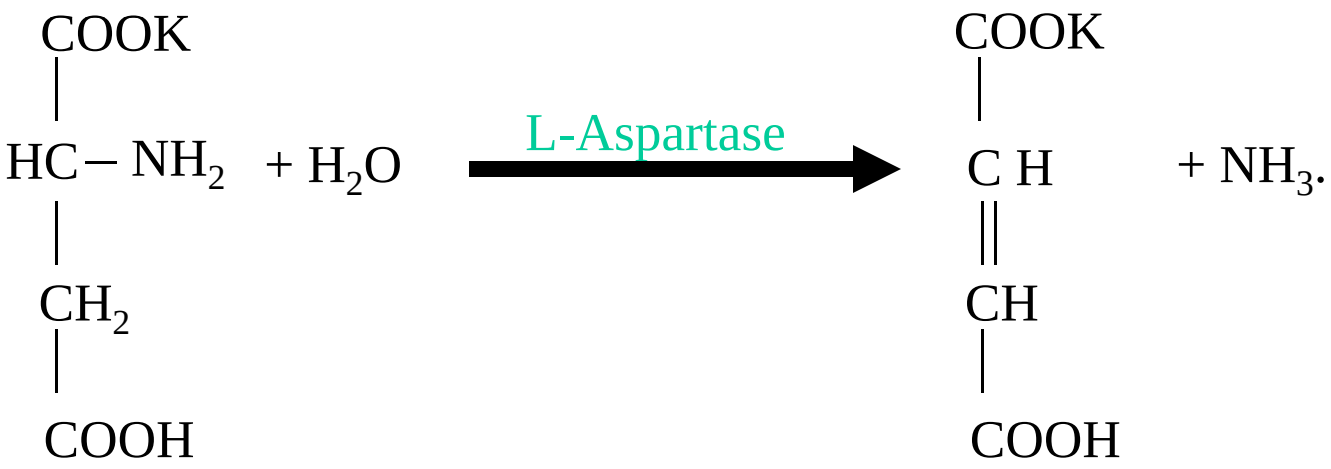
Arylamidase Activity



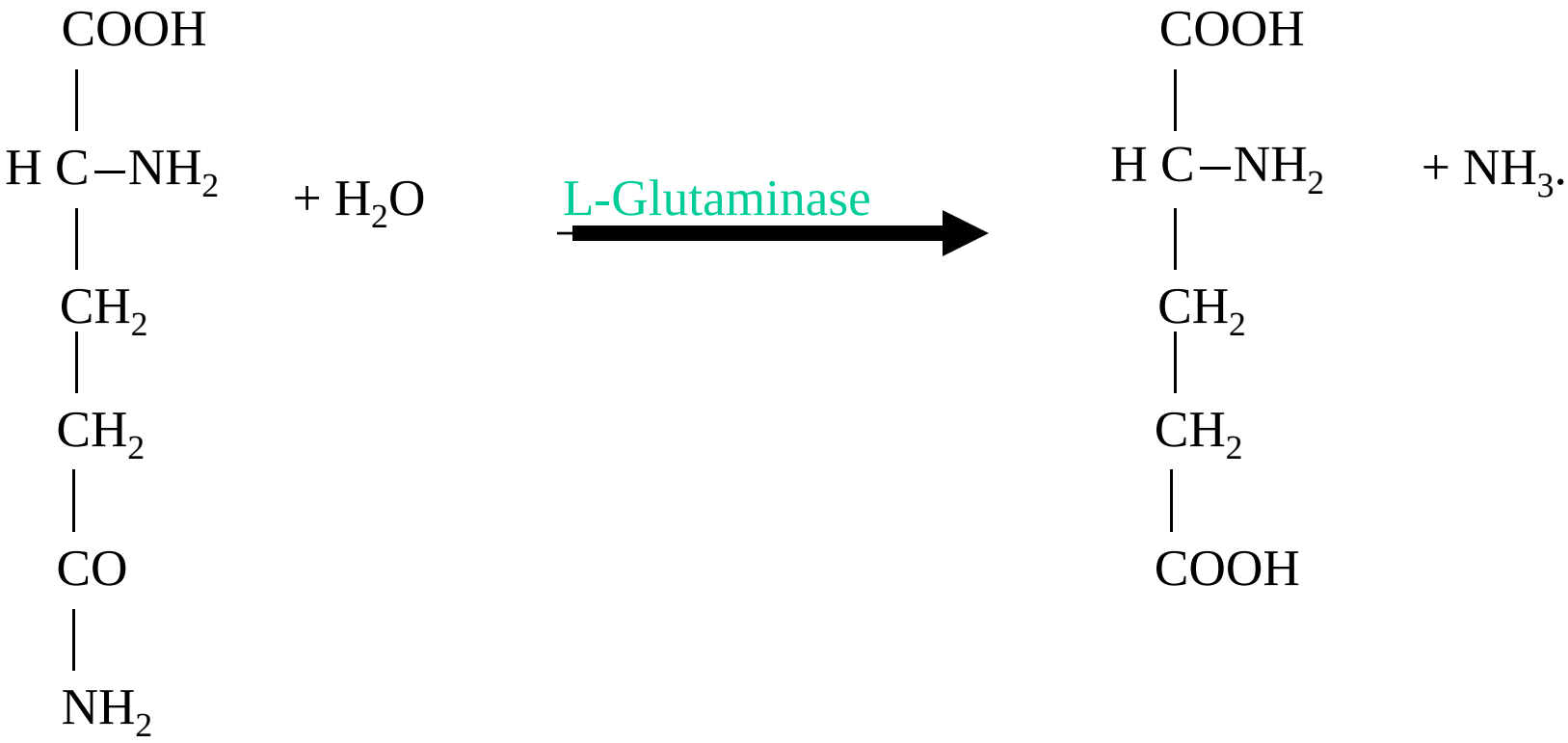
L-Asparaginase activity



L-Aspartase activity

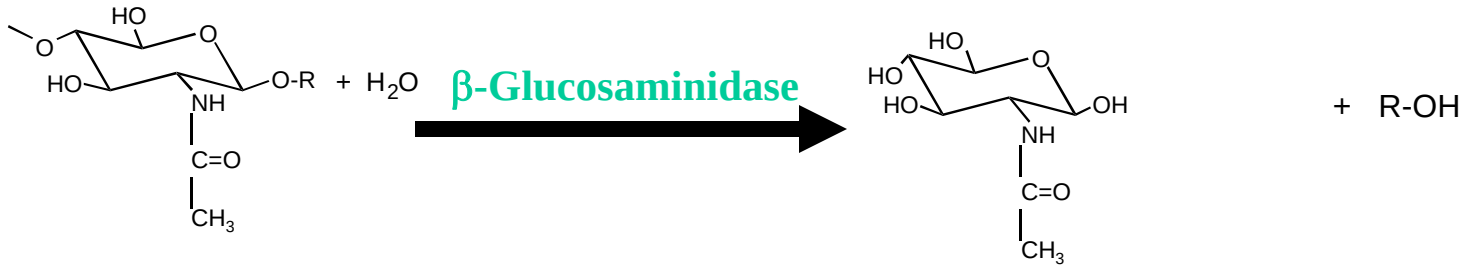


L-Glutaminase activity



Amidase activity

β-Glucosiminidase Activity in Soils

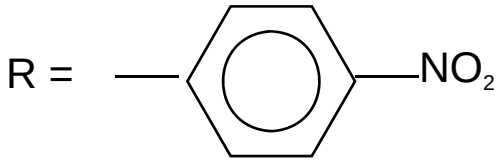


p-Nitrophenyl-*N*-acetyl-β -D- glucosaminide

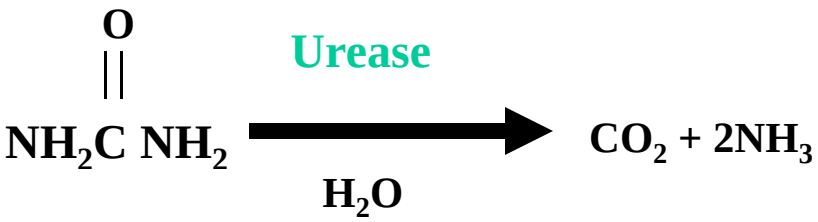
(Substrate for assay)

N -acetyl-β-D-glucosaminide

p-nitrophenol

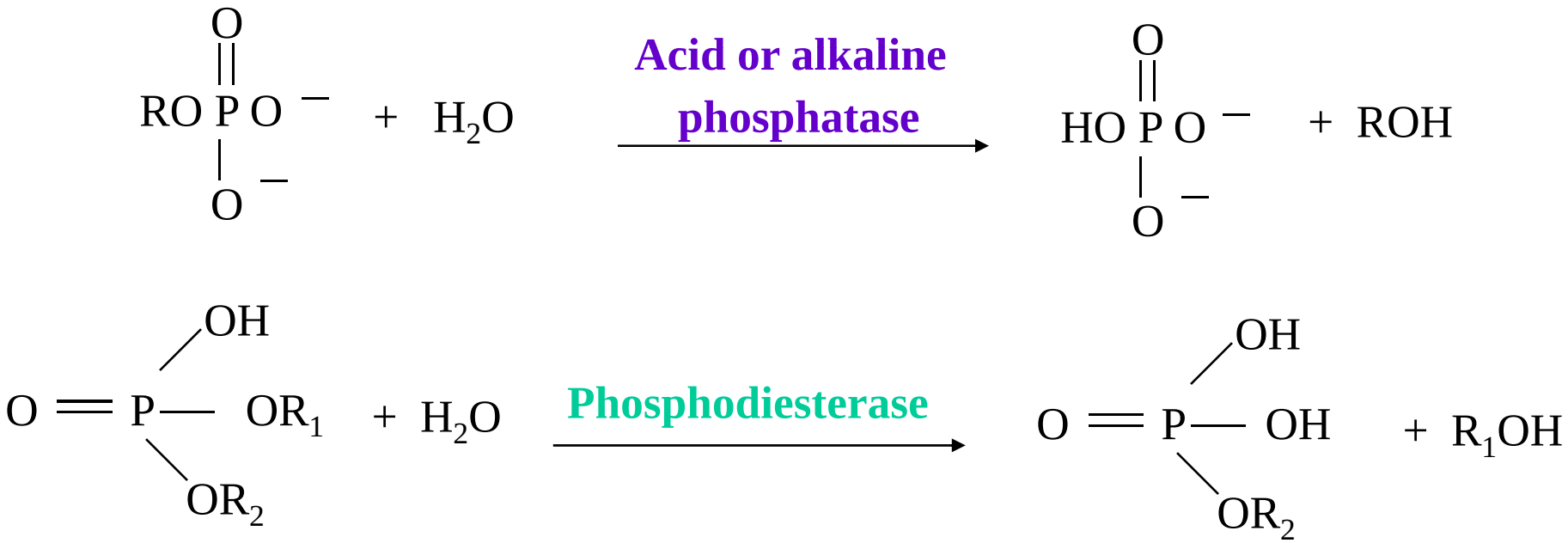


Urease activity



Selected enzyme reactions

- Phosphorus mineralization



Selected enzyme reactions

- Sulfur mineralization

- **Arylsulfatase** is believed to be partly responsible for S cycling in soils as it is involved in the mineralization of organic sulfur compounds to inorganic forms (SO_4^{2-}) for plant uptake (Tabatabai, 1994).
- R= aryl group
- Substrate for assay= *p*-nitrophenyl sulfate

References

Burns, R.G. (1982). Enzyme activity in soil: Location and a possible role in microbial ecology. *Soil Biol. Biochem.* 14: 423-427.

Kiss, S., Dracan-Bularda, M., and Radulescu, D. (1975). Biological significance of enzymes accumulated in soil. *Adv. Agron.* 27: 25-87

Nannipieri, P. (1994) The potential use of soil enzymes as indicators of soil productivity, sustainability, and pollution. In: Soil biota: management in sustainable farming systems.

Tabatabai, M. A. (1994). Soil enzymes. *In* "Methods of Soil Analysis" (R. W. Weaver, J. S. Angle, and P. S. Bottomley, eds.). Part 2. Microbiological and biochemical properties. p. 775-833. SSSA Book Series No. 5, Soil Sci. Soc. Am., Madison, WI.