**[Koch's Postulates and their present Modifications](http://pakagrifarming.blogspot.in/2013/01/kochs-postulates-and-their-present.html)**

In 1884, Robert Koch and Friedrich Loeffler tried to define criteria for identification of any pathogen associated with a particular disease in living organisms. These postulates were further refined by Koch and published in 1890. Koch, primarily set these postulates to establish the association of *Bacillus anthracis* with the anthrax of cattle. And he also established that tuberculosis in human is caused by a different species of bacteria.

## Koch’s postulates

1. The organism must be found on all the diseased host tissue but not on the healthy host.

2. The organism can be isolated from the host and purified on artificial culture medium.

3. The organism from pure culture, when inoculated on the susceptible host must reproduce the symptoms as in step 1.

4. The organism can be re-isolated from the artificially inoculated host on pure culture medium.

## Limitations

Koch’s postulates, although have significant role in the development of microbiology but still have their limitation and Koch himself was aware of this. For example, he believed that leprosy and cholera were caused by microbes but could not fulfill all postulates. In case of cholera, *Vibrio cholerae*, could be isolated from both sick and healthy people, hence a negation of postulate #1.

The limitations of Koch’s postulated were more prominent in case of viral diseases which were not discovered at the time these postulates were formulated.

Most of the viruses which are present in living organisms do not cause disease which is negation of postulate #1. For example, a poliovirus which is present in most of the individual causes paralytic disease in only less than 1% of infected individuals. Similarly most of the viruses cannot be isolated on pure medium or for which not medium has been identified (Negation of postulate #2 and #3). Thomas Rivers, “Father of modern virology” also commented that in some instances when the conditions are not met for Koch’s postulated, then Koch’s postulated become hindrance to work instead of assistance.

## Present Horizons

The application of nucleic acid based methods of microbial identificaion, polymerase chain reaction (PCR) and high throughput analysis have revealed a great deal about the association of highly uncultivable viruses (and which multiplies rapidly) and they are found associated with tissues even without the development of the diseases. The use of these modern methods have sought for a modification of the Koch’s postulates which are otherwise sound.

## Modifications of Koch's Postulates

Fredricks and Relman (1998) modified Koch’s postulates for viruses and other nucleic acids (DNA/RNA) based pathogens.

1. A nucleic acid sequence (DNA/RNA) of known pathogen should be found associated in most of the cases with a disease which can found in those organs or gross anatomical sites which are having symptoms of the disease.

2. Pathogen-associated nucleic acid sequences may or may not be present in fewer numbers from the host or tissues without disease.

3. The copy number (count) of the pathogen-associated nucleic acid sequences should decrease or become undetectable in case of resolution of disease. With clinical recurrence, the case will be vice versa.

4. In case of association of the nucleic acid sequences with the tissue before disease development or when sequence copy number correlates severity of disease or pathology; then the sequence-disease relationship is more likely to be causal relationship.

5. The nature of the microorganism inferred from the available sequence should be consistent with the known biological characteristics of that group.

6. The relationship between the sequence and tissue should be tried to establish at the cellular level; efforts should be made to demonstrate the hybridization of the microbial sequence to the areas of tissue pathology and to visible microorganisms or to areas where microorganism are thought to be involved. These sequence based forms of evidences for microbial causation should be reproducible.



* Hawkswoth DL (2011) Books on insect biodiversity and conservation. Biodiv Conserv 20. doi:10.1007/ s10531-011-0177-y
* Panda T, Pani PK, Mishra N, Mohanty, RB. 2010. A Comparative Account of the Diversity and Distribution of Fungi in Tropical Forest Soils and Sand Dunes of Orissa, India. J Biodiversity, 1: 27–41.
* Pointing SB, Hyde KD. 2001. Bio-Explotation of Filamentous Fungi. Fungal Diversity Research Series, 6: 1–467.
* Sule, I. O. and Oyeyiola, G. P. 2012. Fungi in the Rhizosphere and Rhizoplane of Cassava cultivar TME 419. IJABR Vol. 4(1&2):18 - 30
* Dhillion SS, Gardsjord TL (2004). Arbuscular mycorrhizas influence plant diversity, productivity, and nutrients in boreal grasslands. Canadian Journal of Botany 82:104-114.
* Van Der Heijden EW, Kuyper TW (2001) Laboratory experiments imply the conditionality of mycorrhizal benefits for Salix repens: role of pH and nitrogen to phosphorus ratios. Plant Soil 228:275–290
* Hanson CA, Allison SD, Bradford MA et al. (2008) Fungal taxa target different carbon sources in forest soil. Ecosystems 11:1157-1167.
* Khan MS, Zaidi A, Wani PA (2007) Role of phosphate-solubilizing microorganisms in sustainable agriculture - A review Agronom for Sustain Develop 27:29-43.
* Ogawa Y, Tokumasu S, Tubaki K. 1996. Factors affecting microfungal diversity. Mycoscience, 37: 377–380.
* Graham, J.H., 2001. What do root pathogens see in mycorrhizas?. New Phytologist 149, 357–359.
* Read, D. J. and Smith, S. E., 2008. Mycorrhizal Symbiosis, 3rd ed. San Diego, CA: Academic Press