

# HORIZONTAL AND VERTICAL GENE TRANSFER

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## Contents

- 1. Gene Transfer
- 2. Horizontal Gene Transfer
- 3. Vertical Gene Transfer
- Glossary
- Bibliography
- Biographical Sketch

## Summary

Organisms evolve by gene loss and gain. They have gained many genes by horizontal gene transfer under selection pressure. They also gained new functions by mutation, rearrangement, and recombination of genes. Genetic information is inherited by vertical gene transfer.

### 1. Gene Transfer

The genetic information to confer functions that distinguish between species is acquired by the introduction of the genes (horizontal gene transfer), or the mutation, rearrangement, or recombination of genes. Genetic information is inherited by the transmission of existing genes from ancestors to descendants (vertical gene transfer).

### 2. Horizontal Gene Transfer

Accumulation of genome sequence information has identified candidates of horizontally transferred genes among and between species. Most knowledge about horizontal gene transfer has been obtained from experience with prokaryocytes. Analysis of the genes of *E.coli* and *Salmonella* shows that 17% of the genomes were acquired by horizontal gene transfer during the past 100 million years. Considerable genetic flux seems to be occurring. Studies of bacterial adaptation have contributed greatly to understanding the role of horizontal gene transfer in evolution. Antibiotic resistance genes have been disseminated among human and animal bacteria by mobile genetic elements such as plasmids, bacteriophages, and transposons, and bacteria have adapted rapidly to strong selective pressure. Under the selective pressure of polluted environments it has been demonstrated that gene clusters involved in the catabolism of xenobiotics in the environments have been disseminated by mobile genetic elements through horizontal gene transfer. Virulent determinants of pathogenic bacteria are also thought to have been disseminated by plasmids through horizontal gene transfer, creating new bacterial species when acquired. Natural selection has favored the new bacterial species. The existence of remnants of phage or plasmid genes adjacent to the gene clusters in the

bacterial chromosome suggests the involvement of horizontal gene transfer. When the genes of bacteriophages or plasmids are incorporated by transduction or conjugation, and the bacteriophages or plasmids are rendered inactive by deletion or insertional inactivation, the incorporated genes are fixed and inherited. The acquisition of virulence or other functions by mobile elements is a rapid process, but that by fixation in the chromosome is slow.

Mobile elements such as transposons, viruses, and bacteria probably operate to evolve eukaryocytes in the same way as bacterial mobile elements. *In vitro*, genes to confer functions can be introduced into eukaryocytes by transfection or conjugation. Retrovirus infection or hepatitis B virus infection transfers the viral genes to the chromosome of the host. These are examples of horizontal gene transfer in humans. Bacterial and viral DNA are thought to be constantly being integrated in the chromosomes of plants and animals by conjugation, transformation, and transduction. Transferred genes may confer new functions to the incorporated cells, and when they are incorporated into the germ line and fixed, the genetic information will be transmitted to the next generation.

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### Biographical Sketch

**Michio Imawari** was born in 1947. He graduated from the University of Tokyo in 1972 and obtained a degree as a Bachelor of Medicine. He studied medicine, gastroenterology, and biochemistry at the University of Tokyo, and obtained a degree of Doctor of Medical Science from the University of Tokyo in 1979. He is currently a professor of medicine at Jichi Medical School.