

Examples of R Genes

In 1992, the first R gene, the maize *Hm1* gene, was located, isolated, and sequenced, and its function was described at the molecular level. The *Hm1* R gene makes corn plants of certain varieties resistant to race 1 of the fungus *Cochliobolus carbonum*, which causes a leaf spot disease on susceptible corn varieties. Race 1 of *C. carbonum*, the asexual stage of which is *Bipolaris (Helminthosporium) carbonum*, produces a host specific toxin, the HC toxin. The toxin is a pathogenicity factor for race 1 because the latter must produce HC toxin if it is to infect the corn varieties that lack the *Hm1* gene and are susceptible to the fungus. However, in corn varieties resistant to race 1, expression of the *Hm1* gene results in the production of an enzyme called HC toxin reductase. This enzyme reduces and thereby detoxifies the HC toxin and in that way keeps the plants free from infection by the fungus. If the HC toxin gene of some race 1 isolates is inactivated artificially, these isolates lose the ability to infect corn varieties that do not carry the *Hm1* gene and, therefore, the genetics of this host–pathogen system are not quite the same as in the typical gene-for-gene systems.

Within 3 years after isolation of the *Hm1* gene, more than a dozen plant R genes that conform to the classic gene-for-gene relationship were isolated from plants, sequenced, and transferred and expressed in other, susceptible, plants. The first such gene was the *Pto* gene of tomato, so called because it confers resistance in tomato to the bacterial speck-causing strains of *P. syringae* pv. *tomato* that carry the avirulence gene *avrPto*. The protein encoded by the *Pto* R gene appears to be a **serine–threonine protein kinase**, an enzyme suspected to play a role in **signal transduction leading to the hypersensitive response**. The *Pto* R gene appears to be one of five to seven homologous R genes that exist as a cluster on one of the tomato chromosomes. Some of the other R genes isolated from plants include the tomato *Cf2*, *Cf4*, *Cf5*, and *Cf9* genes, which confer resistance to the leaf mold-causing fungus *Cladosporium fulvum* races 2, 4, 5, and 9 that carry the avirulence genes *avr2*, *avr4*, *avr5*, and *avr9*, respectively; the tobacco *N1* gene, which confers resistance to TMV; the flax *L6* gene, which confers resistance to the rust fungus *Melampsora lini* race 6 carrying the *avr6* gene; the rice *Xa21* gene, which confers resistance to many races of the leaf-spotting bacterium *Xanthomonas oryzae*; and several *Arabidopsis* R genes.

Classes of Plant R gene Proteins		
Class	Function	Example of R gene
I	Membrane-associated, transcription regulating, mediating broad-spectrum resistance	RPW8
II	Cytoplasmic signal-transducing serine-threonine protein kinase	<i>Pto</i>
III	Extracellular LRRs with transmembrane anchor	<i>Cf-2-Cf-9</i>
IV	Extracellular LRRs, with a transmembrane receptor and a cytoplasmic serine-threonine kinase	Xa21
V	Cytoplasmic, membrane associated. Contain LRRs, NBS, and TIR domains	RPP5, N1, L6, RRPP
VI	Also cytoplasmic, membrane associated. Contain LRRs, NBS, and a coiled coil domain	RPM1, RPS2