Biolistic® Particle Delivery System

Bibliography

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Introduction

The Biolistic system is an instrument for the delivery of genetic substances directly into intact cells and tissues.

The Biolistic process has been used to successfully transform both agricultural and non-agricultural plants, animal cells, insect and fish embryos, algae, fungi, pollen, bacteria, and intracellular organelles.

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Reference Tables

Table 1. Stable Transformation of Plants by the Biolistic Process

Plant Species	Tissue Bombarded	Plants Recovered?	Reference
Arabidopsis	roots	yes, progeny	81
Bean	meristems	yes, progeny	69
Cotton	meristem	yes, progeny	53
Cranberry	stems	yes	82
Liriodendron	embryogenic culture	yes	103
Maize	suspension culture	non-regenerable*	43
	embryogenic culture	yes	28, 29
	embryos	yes, field test	47
Oat	embryogenic callus	yes, progeny	85
Orchid	protocorm	yes	48
Papaya	somatic embryos	yes	24
Picea	embryogenic callus	yes	22
	somatic embryos	no	68
Populus	cultured nodules	yes	56
Rice	embryos	yes	12
	embryogenic callus	yes, progeny	50
Sorghum	suspension culture	no	30
Soybean	embryos	not attempted	14
	apical meristem	yes	15, 59
Sugarcane	embryogenic callus	yes	6
Sweet Potato	leaves	no	65
Tobacco	suspension culture	non-regenerable*	42, 70, 71
	leaves	yes	42, 95
	leaves, chloroplasts	yes, progeny	88, 89
Wheat	embryogenic callus	yes, progeny	98

* Plants can not be regenerated from these lines of suspension culture cells even prior to bombardment.

Table 2. Transient expression of DNA delivered into various plant tissues by the Biolistic process*

Tissue Type and Species	Reporter Gene (Promoter/coding region)	Reference
Tissue Culture Cells		
Tobacco	35S/GUS	41, 42, 59
	35S/LUC	59
	35S/CAT	18
	chloroplast promoter/CAT††	18
Soybean, Wheat, Rice	Adh/GUS or 35S/CAT	57, 61, 100
Corn	Adh/GUS	41, 100
	35S/CAT	39
	PAT/GUS	7
Barley	35S/CAT	36
	GUS, NPTII	58
Larix	GUS	21
Picea	35S/GUS	9
	EM/GUS	9
Leaves		
Tobacco	35S/GUS	42, 96
Corn	35S/R†	51
Wheat	Adh/GUS	61
Seedlings (various tissues)		
Corn	35S/R	51
Eggplant	35S/luciferase	59
Rice, Barley, Oats, Cucumber,Tobacco, *Arabidopsis*	35S/CAT, maize ubiquitin/LUC, or rice phytochrome/CAT	7
Seed Tissues		
Corn aleurone or embryo	Adh/GUS	41, 61
	35S/GUS or *R*	51
	Adh/LUC or CAT	45
	Bz1 or *A1*§ /LUC	28, 45
	A1 or *Bz1* genomic clones**	45
Barley embryos	35S/CAT	36
Corn, Rice embryos	Adh/GUS	8
Wheat, apical	Adh/GUS	61
Epidermal Tissues		
Onion	35S/CAT	46
Corn	35S/R	51

Table 2 continued

Tissue Type and Species	Reporter Gene (Promoter/coding region)	Reference
Floral Tissues		
Tobacco anthers or petals	35S/GUS	96
Wheat meristem		49
Pollen and Microspores		
Tobacco	Pollen promoter or 35S/GUS	96
Barley	Viral mediated, wheat dwarf virus	61, 99
Organelles		
Tobacco chloroplast	Chloroplast Promotor or 35S/GUS	18

Footnotes to Table 2:

* Abbreviations: 35S, 35S promoter from cauliflower mosaic virus; Adh, promoter from the Alcohol dehydrogenase 1 gene of maize; GUS, ß-glucuronidase; CAT, chloramphenicol acetyltransferase; LUC, luciferase; NPTII, neomycin phosphotransferase II.

† The R gene from maize is one of the regulatory genes of the anthocyanin biosynthetic pathway. Production of the product of the R gene in cells of mutants lacking a functional R gene results in expression of the pathway and therefore pigment production in the affected cell.

§ A1 and Bz1 are structural genes of the maize anthocyanin biosynthetic pathway.

** Introduction of the A1 or Bz1 genomic clones into tissue from the appropriate mutant plant results in pigment production in bombarded cells.

†† Construct specifically expressed in the chloroplast.

Table 3. Transformation of organisms other than higher plants by the Biolistic process

Cell Type and Intracellular Location	Marker	Reference
Animal Cells		
NIH 3T3	neomycin	33, 109
CHO, lymphocytes	ADH, ß-gal, neomycin	25
mouse ear	HGH	90
mouse ear, liver, skin	actin/luciferase	35
Insect Embyros		
Drosophila melanogaster	ß-gal	2
Algae		
Chlamydomonas reinhardtii	arginosuccinate lyase	19
Chlamydomonas reinhardtii	nitrate reductase	38
Chlamydomonas reinhardtii	oxygen evolving enhancer	18
Chlamydomonas reinhardtii	neomycin, kanamycin	52
Chlamydomonas reinhardtii	*dum*1	66
Chlamydomonas reinhardtii, chloroplasts	*atp*B	3, 4, 5
Chlamydomonas reinhardtii, chloroplasts	*pet*D/GUS	73
Chlamydomonas reinhardtii, chloroplasts	*atp*B	86
Fungi:		
Saccharomyces cerevisiae	*ura*3	1, 34
Saccharomyces pombe	*leu*1 or *ura*4	1
Neurospora crassa	*qa*2	1
S. cerevisiae, mitochondria	oxi1	26
S. cerevisiae, mitochondria		34
Podospora anserina, mitochondria	Premature senesence	17
Cryptococcus neoformans	*ade*2	94
Bacteria		
Bacillus megaterium		83
Agrobacterium tumefaciens	antibiotics	84
Erwinia	antibiotics	84
Escherichia coli	antibiotics	84
Pseudomonas	antibiotics	84

Bibliography

This bibliography is a listing of references in scientific literature citing microprojectile bombardment.

Reviews	33 , 37, 40, 44, 60, 62, 63, 64, 74, 75, 76, 77, 78, 79, 93, 102, 110
Algae	3, 4, 5, 19, 38, 52, 66, 73, 86
Bacteria	83, 84
Fish Embryos	107
Fungi	1, 17, 26, 34, 92, 94
Insect Embryos	2
Mammalian Cells	25, 33, 35, 76, 90, 93, 104, 108, 109
Onion	46
Orchid	48
Organelles	
Chloroplasts	3, 4, 18, 31, 106
Mitochondria	26, 34
Plants	
Arabidopsis	7, 80, 81
Brassica	77
Barley	7, 16, 36, 58
Bean	69
Cotton	53
Cucumber	7
Eggplant	59
Maize	8, 27, 28, 29, 39, 41, 43, 45, 47, 51, 61, 67, 101
Millet	91
Oat	7, 85
Pollen/Microspores	16, 55, 96
Rice	7, 8, 12, 50, 57, 61, 99, 100, 105
Sorghum	30
Soybean	11, 13, 14, 15, 54, 55, 99, 100
Sugarcane	6
Sweet Potato	65
Tobacco	18, 32, 42, 59, 70, 71, 72, 88, 89, 95
Wheat	10, 49, 61, 96, 97, 98, 99
Woody Species	
Cranberry	82
Larix	21
Liriodendron	103
Papaya	24
Picea	9, 22, 23, 68
Pinus	87
Populus	56

References

*1. Armaleo, D., Ye, G.-N., Klein, T. M., Shark, K. B., Sanford, J. C., and Johnston, S. A., Biolistic nuclear transformation of *Saccharomyces cerevisiae* and other fungi, *Curr. Genet.*, **17**, 97-103 (1990).

*2. Baldarelli, R. M., and Lengyel, J. A., Transient expression of DNA after ballistic introduction into *Drosophila* embryos, *Nucl. Acids Res.*, **18**, 5903-5904 (1990).

*3. Blowers, A. D., Bogorad, L., Shark, K. B., and Sanford, J. C., Studies on *Chlamydomonas* chloroplast transformation: foreign DNA can be stably maintained in the chromosome, *Plant Cell*, **1**, 123-132 (1989).

*4. Boynton, J. E., Gillham, N. W., Harris, E. H., Hosler, J. P., Johnson, A. M., Jones, A. R., Randolph-Anderson, B. L., Robertson, D., Klein, T. M., Shark, K. B., and Sanford, J. C., Chloroplast transformation in *Chlamydomonas* with high velocity microprojectiles, *Science*, **240**, 1534-1538 (1988).

*5. Boynton, J. E., Gillham, N. W., Harris, E. H., Hosler, J. P., Johnson, A. M., Randolph-Anderson, B. L., Robertson, D., Klein, T. M., and Sanford, J. C., Transformation of a chloroplast ATPase mutant of Chlamydomonas using high velocity microprojectiles to deliver a wild type chloroplast DNA fragment, *Molecular Biology of Chloroplasts and Mitochondria*, Cold Spring Harbor, New York, 1987.

6. Bower, B., and Birch, R. G., Transgenic sugarcane plants via microprojectile bombardment, *Plant Journal*, **2**, 409-416 (1992).

*7. Bruce, W. B., Christensen, A. H., Klein, T., Fromm, M., and Quail, P. H., Photoregulation of a phytochrome gene promoter from oat transferred into rice by particle bombardment, *Proc. Natl. Acad. Sci. USA*, **86**, 9692-9696 (1989).

*8. Cao, J., Wang, Y.-C., Klein, T. M., Sanford, J., and Wu, R. Transformation of rice and maize using the biolistic process, from *Symposium on Plant Gene Transfer, UCLA Symposium*, 21-33, Alan R. Liss, Inc. (1990).

*9. Charest, P.J., Calero, N., Lachance, D., Datla, R. S. S., Duchesne, L. C., and Tsang, E. W. T., Microprojectile-DNA delivery in conifer species factors affecting assessment of transient gene expression using the β-glucuronidase reporter gene, *Plant Cell Rep.*, **12**: 189-193 (1993).

*10. Chibbar, R. N., Kartha, K. K., Leung, N., Qureshi, J., and Caswell, K., Transient expression of marker genes in immature zygotic embryos of spring wheat (*Triticum aestivum*) through microprojectile bombardment, *Genome*, **34**, 453-460 (1991).

11. Christou, P., Soybean transformation by electric discharge particle acceleration, *Physiol. Plant.*, **79**, 210-212 (1990).

12. Christou, P., Ford, T. L., and Kofron, M., The development of a variety-independent gene-transfer method for rice, *TIBTECH*, **10**, 240-246 (1992).

13. Christou, P., McCabe, D. E., Martinell, B. J., and Swain, W. F., Soybean genetic engineering - commercial production of transgenic plants, *TIBTECH*, **8**, 145-151 (1990).

14. Christou, P., McCabe, D. E., and Swain, W. F., Stable transformation of soybean callus by DNA-coated gold particles, *Plant Physiol.*, **87**, 671-674 (1988).

15. Christou, P., Swain, W. F., Yang, N.-S., and McCabe, D. E., Inheritance and expression of foreign genes in transgenic soybean plants, *Proc. Natl. Acad. Sci. USA*, **86**, 7500-7504 (1989).

*16. Creissen, G., Smith, C., Francis, R., Reynolds, H., and Mullineaux, P., *Agrobacterium*- and microprojectile-mediated viral DNA delivery into barley microspore-derived cultures, *Plant Cell Rep.*, **8**, 680-683 (1990).

*17. Cummings, D. J., Domenico, J. M., and Sanford, J. C., Mitochondrial DNA from *Podospora anserina*: transformation to senescence via projectile injection of plasmids, *Molec. Biol. Aging*, **123**, 91-101 (1990).

*18. Daniell, H., Vivekananda, J., Nielsen, B. L., Ye, G. N., Tewari, K. K., and Sanford, J. C., Transient foreign gene expression in chloroplasts of cultured tobacco cells after biolistic delivery of chloroplast vectors, *Proc. Natl. Acad. Sci. USA*, **87**, 88-92 (1990).

19. Debuchy, R., Purton, S., and Rochaix, J.-D., The argininosuccinate lyase gene of *Chlamydomonas reinhardtii*: an important tool for nuclear transformation and for correlating the genetic and molecular maps of the ARG7 locus, *EMBO J.*, **8**, 2803-2809 (1989).

*20. Duchesne, L. C. and Charset, P. J., Transient expression of the β-glucuronidase gene in embryogenic callus of *Picea mariana* following microprojection, *Plant Cell Rep.*, **10**, 191-194 (1991).

*21. Duchesne, L.C., Lelu, M. A.,Von Aderkas P., and Charest, P. J., Microprojectile-mediated DNA delivery in haploid and diploid embryogenic cells of *Larix* spp., *Can. J. For. Res.*, **23**, 312-316 (1993).

22. Ellis, D. D., McCabe, D., McInnis, S., Ramachandran, R., Russell, D. R., Wallace, K. M., Martinell, B. J., Roberts, D. R., Raffa, K. F., and McCown, B. H., Stable transformation of *Picea glauca* by particle acceleration, *Bio/Technol.*, **11**, 84-89 (1993).

23. Ellis, D. D., McCabe, D., Russell, D., Martinell, B., and McCown, B. H., Expression of inducible angiosperm promotors in a gymnosperm, *Picea glauca* (white spruce), *Plant Molec. Biol.*, **17**, 19-27 (1991).

*24. Fitch, M. M., Manshardt, R. M., Gonsolves, D., Slightom, J. L., Quemada, H., and Sanford, J. C., Stable transformation of papaya via microprojectile bombardment, *Plant Cell Rep.*, **9**, 189-194 (1990).

*25. Fitzpatrick-McElligott, S., Gene transfer to tumor-infiltrating lymphocytes and other mammalian somatic cells by microprojectile bombardment, *Bio/Technol.*, **10**:1036-1040 (1992).

*26. Fox, T. D., Sanford, J. C., and McMullin, T. W., Plasmids can stably transform yeast mitochondria lacking endogenous mtDNA, *Proc. Natl. Acad. Sci USA*, **85**, 7288-7292 (1988).

*27. Fromm, M. E., Morrish, F., Armstrong, C., Williams, R., Thomas, J., and Klein, T. M., Inheritance and expression of chimeric genes in the progeny of transgenic maize plants, *Bio/Technol.*, **8**, 833-839 (1990).

*28. Goff, S. A., Klein, T. M., Roth, B. A., Fromm, M. E., Cone, K. C., Radicella, J. P., and Chandler, V. L., Transactivation of anthocyanin biosynthetic genes following transfer of B regulatory genes into maize tissues, *EMBO J.*, **9**, 2517-2522 (1990).

*29. Gordon-Kamm, W. J., Spencer, T. M., Mangano, M. L., Adams, T. R., Daines, R. J., Start, W. G., O'Brien, J. V., Chambers, S. A., Adams, Jr., W. R., Willetts, N. G., Rice, T. B., Mackey, C. J., Krueger, R. W., Kausch, A. P., and Lemaux, P. G., Transformation of maize cells and regeneration of fertile transgenic plants, *Plant Cell*, **2**, 603-618 (1990).

*30. Hagio, T., Blowers, A. D., and Earle, E. D., Stable transformation of sorghum cell cultures after bombardment with DNA-coated microprojectiles, *Plant Cell Rep.*, **10**, 260-264 (1991).

31. Haring, M. A., and De Block, M., New roads towards chloroplast transformation in higher plants, *Physiol. Plant.*, **79**, 218-220 (1990).

32. Iida, A., Seki, M., Kamada, M., Yamada, Y., and Morikawa, H., Gene delivery into cultured plant cells by DNA-coated gold particles accelerated by a pneumatic particle gun, *Theor. Appl. Genet.*, **80**, 813-816 (1990).

*33. Johnston, S. A., Biolistic transformation: microbes to mice, *Nature*, **346**, 776-777 (1990).

*34. Johnston, S. A., Anziano, P. Q., Shark, K., Sanford, J. C., and Butow, R. A., Mitochondrial transformation in yeast by bombardment with microprojectiles, *Science*, **240**, 1538-1541 (1988).

*35. Johnston, S. A., Reidy, M., DeVit, M. J., Sanford, J. C., McElligott, S., and Williams, R. S., Biolistic transformation of animal tissue, *In Vitro Cell. Develop. Biol.*, **27P**, 11-12 (1991).

*36. Kartha, K. K., Chibbar, R. N., Georges, F., Leung, N., Caswell, K., Kendall, E., and Qureshi, J., Transient expression of chloramphenicol acetyltransferase (CAT) gene in barley cell cultures and immature embryos through microprojectile bombardment, *Plant Cell Rep.*, **8**, 429-432 (1989).

*37. Kikkert,J.R., The Biolistic PDS-1000/He device, *Plant Cell Tissue Organ Cult.*, **33**, 221-226, (1993).

38. Kindle, K. L., Schnell, R. A., Fernández, E., and Lefebvre, P. A., Stable nuclear transformation of *Chlamydomonas* using the *Chlamydomonas* gene for nitrate reductase, *J. Cell Biol.*, **109**, 2589-2601 (1989).

*39. Klein, T. M., Fromm, M., Weissinger, A., Tomes, D., Schaaf, S., Sletten, M., and Sanford, J. C., Transfer of foreign genes into intact maize cells with high-velocity microprojectiles, *Proc. Natl. Acad. Sci. USA*, **85**, 4305-4309 (1988).

*40. Klein, T. M., Goff, S. A., Roth, B. A., and Fromm, M. E., Applications of the particle gun in plant biology, in Proceedings of the VIII International Congress on Plant Tissue and Cell Culture, June 24-29, 1990, pp. 56-66, Amsterdam.

*41. Klein, T. M., Gradziel, T., Fromm, M. E., and Sanford, J. C., Factors influencing gene delivery into *Zea mays* cells by high-velocity microprojectiles, *Bio/Technol.*, **6**, 559-563 (1988).

*42. Klein, T. M., Harper, E. C., Svab, Z., Sanford, J. C., Fromm, M. E., and Maliga, P., Stable genetic transformation of intact *Nicotiana* cells by the particle bombardment process, *Proc. Natl. Acad. Sci. USA*, **85**, 8502-8505 (1988).

*43. Klein, T. M., Kornstein, L., Sanford, J. C., and Fromm, M. E., Genetic transformation of maize cells by particle bombardment, *Plant Physiol.*, **91**, 440-444 (1989).

*44. Klein, T. M., Roth, B. A., and Fromm, M. E., Advances in direct gene transfer into cereals, in "Genetic Engineering; Principles and Methods," Vol. 11, J. K. Setlow (ed.), Plenum Press, New York (1989).

*45. Klein, T. M., Roth, B. A., and Fromm, M. E., Regulation of anthocyanin biosynthetic genes introduced into intact maize tissues by microprojectiles, *Proc. Natl. Acad. Sci. USA*, **86**, 6681-6685 (1989).

*46. Klein, T. M., Wolf, E. D., Wu, R., and Sanford, J. C., High-velocity microprojectiles for delivering nucleic acids into living cells, *Nature*, **327**, 70-73 (1987).

*47. Koziel, M.G., Beland, G. L., Bowman, C., Carozzi, N. B., Crenshaw, R., Crossland, L., Dawson, J., Desai, N., Hill, M., Kadwell, S., Launis, K., Lewis, K., Maddox, D., McPherson, K., Meghji, M. R., Merlin, E., Rhodes, R., Warren, G.W., Wright, and M., Evola, S., Field performance of elite transgenic maize plants expressing an insecticidal protein derived from *Bacillus thuringensis*, *Bio/Technol.*, **11**, 194-200 (1993).

*48. Kuehnle, A. R., and Sugii, N., Transformation of *Dendrobium* orchid using particle bombardment of protocorms, *Plant Cell Rep.*, **11**, 484-488 (1992).

49. Leduc, N., Iglesias, V. A., Bilang, R., Zhang, S., Gisel, A., Sautter, and C., Potrykus, I., Gene transfer to flower meristem cells by particle bombardment. Keystone Symposium On Evolution And Plant Development, Taos, New Mexico, USA, January, 1993.

50. Li, L., Qu, R., de Kochko, A., Fauquet, C., and Beachy, R. N., An improved rice transformation system using the biolistic method, *Plant Cell Rep.*, **12**, 250-255 (1993).

*51. Ludwig, S. R., Bowen, B., Beach, L., and Wessler, S. R., A regulatory gene as a novel visible marker for maize transformation, *Science*, **247**, 449-450 (1990).

52. Mayfield, S. P., and Kindle, K. L., Stable nuclear transformation of *Chlamydomonas reinhardtii* by using a *C. reinhardtii* gene as the selectable marker, *Proc. Natl. Acad. Sci. USA*, **87**, 2087-2091 (1990).

53. McCabe, D. E., and Martinell, B. J., Transformation of elite cotton cultivars via particle bombardment of meristems, *Bio/Technol.*, **11**, 596-598 (1993).

54. McCabe, D. E., Swain, W. F., and Martinell, B. J., Pollen-mediated plant transformation (European Patent Publication Number 0 270 356), 1988.

55. McCabe, D. E., Swain, W. F., Martinell, B. J., and Christou, P., Stable transformation of soybean (*Glycine max*) by particle acceleration, *Bio/Technol.*, **6**, 923-926 (1988).

56. McCown, B. H., McCabe, D. E., Russell, D. R., Robison, D. J., Barton, K. A., and Raffa, K. F., Stable transformation of *Populus* and incorporation of pest resistance by electric discharge particle acceleration, *Plant Cell Rep.*, **9**, 590-594 (1991).

57. McElroy, D., Zhang, W., Cao, J., and Wu, R., Isolation of an efficient actin promoter for use in rice transformation, *Plant Cell*, **2**, 163-171 (1990).

58. Mendel, R. R., Müller, B., Schulze, J., Kolesnikov, V., and Zelenin, A., Delivery of foreign genes to intact barley cells by high-velocity microprojectiles, *Theor. Appl. Genet.*, **78**, 31-34 (1989).

59. Morikawa, H., Iida, A., and Yamada, Y., Transient expression of foreign genes in plant cells and tissues obtained by a simple biolistic device (particle-gun), *Appl. Microbiol. Biotechnol.*, **31**, 320-322 (1989).

60. Nelson, T., New horses for monocot gene jockeys, *Plant Cell*, **2**, 589 (1990).

61. Oard, J. H., Paige, D. F., Simmonds, J. A., and Gradziel, T. M., Transient gene expression in maize, rice, and wheat cells using an airgun apparatus, *Plant Physiol.*, **92**, 334-339 (1990).

62. Potrykus, I., Gene transfer to cereals: an assessment, *TIBTECH*, **7**, 269-273 (1989).

63. Potrykus, I., Gene transfer to plants: assessment and perspectives, *Physiol. Plant.*, **79**, 125-134 (1990).

64. Potrykus, I., Gene transfer to plants: assessment of published approaches and results, *Annu. Rev. Plant Physiol. Plant Mol. Biol.*, **42**, 205-225 (1991).

*65. Prakesh, C. S., and Varadarajan, U., Genetic transformation of sweet potato by particle bombardment, *Plant Cell Rep.*, **11**, 53-57 (1992). [*Ipomoea batatas*]

*66. Randolph, A.B.L., Boynton, J. E., Gillham, N. W., Harris, E. H., Johnson, A. M., Dorthu, M. P., and Matagne, and Further, R. F., Characterization of the respiratory deficient *dum*1 mutation of *Chlamydomonas reinhardtii* and its use as a recipient for mitochondrial transformation, *Mol. Gen. Genet.*, **238**, 235-244 (1993).

67. Reggiardo, M. I., Arana, J. L., Orsaria, L. M., Permingeat, H. R., Spitteler, M. A., and Vallejos, R. H., Transient transformation of maize tissues by microprojectile bombardment, *Plant Sci.*, **75**, 237-243 (1991).

*68. Robertson, D., Weissinger, A. K., Ackley, R., Glover, S., and Sederoff, R. R., Genetic transformation of Norway spruce (*Picea abies* (L.) Karst) using somatic embryo explants by microprojectile bombardment, *Plant Molec. Biol.*, **19**, 925-935 (1992).

69. Russell, D. R., Wallace, K. M., Bathe, J. H., Martinell, B. J., and McCabe, D. E., Stable transformation of *Phaseolus vulgaris* via electric-discharge mediated particle acceleration, *Plant Cell Rep.*, **12**, 165-169 (1993).

*70. Russell, J. A., Roy, M. K., and Sanford, J. C., Cell injury as a limiting factor in stable biolistic plant transformation, *In Vitro Cell. Develop. Biol.*, **26**, 43A (1990).

*71. Russell, J. A., Roy, M. K., and Sanford, J. C., Major improvements in biolistic transformation of suspension cultured tobacco cells, *In Vitro Cell. Develop. Biol.*, **28P**, 97-105, (1992).

*72. Russell, J. A., Roy, M. K., and Sanford, J. C., Physical trauma and tungsten toxicity reduce the efficiency of biolistic transformation, *Plant Physiol.*, **98**, 1050-1056 (1992).

*73. Sakamoto, W., K.L. Kindle, and Stern, D. B., *In-vivo* analysis of *Chlamydomonas* chloroplast *pet*D gene expression using stable transformation of β-glucuronidase translational fusions, *Proc. Natl. Acad. Sci., U S A*, **90**, 497-501 (1993).

*74. Sanford, J. C., Biolistic plant transformation, *Physiol. Plant.*, **79**, 206-209 (1990).

*75. Sanford, J. C., The biolistic process, *TIBTECH*, **6**, 299-302 (1988).

*76. Sanford, J. C., The biolistic process - an emerging tool for research and clinical applications, from "Biomedical Engineering: Opening New Doors," *Proceedings of the 1990 Annual Meeting of the BioMedical Engineering Society*, D. C. Milulecky and A. M. Clarke (eds.), New York University Press, New York, 1990.

*77. Sanford, J. C., Devit, M. J., Russell, J. A., Smith, F. D., Harpending, P. R., Roy, M. K., and Johnston, S. A., An improved, helium-driven biolistic device, *Technique*, **3**, 3-16 (1991).

*78. Sanford, J. C., Klein, T. M., Wolf, E. D., and Allen, N., Delivery of substances into cells and tissues using a particle bombardment process, *Particulate Sci. Technol.*, **5**, 27-37 (1987).

*79. Sanford, J. C., Smith, F. D., and Russell, J. A., Optimizing the biolistic process for different biological applications, *Meth. Enzymol.*, **217**, 483-509 (1993).

80. Seki, M., Komeda, Y., Iida, A., Yamada, Y., and Morikawa, H., Transient espression of β-glucuronidase in *Arabidopsis thaliana* leaves and roots and *Brassica napus* stems using a pneumatic particle gun, *Plant Molec. Biol.*, **17**, 259-263 (1991).

81. Seki, M., Shigemoto, N., Komeda, Y., Imamura, J., Yamada, Y., and Morikawa, H., Transgenic *Arabidopsis thaliana* plants obtained by particle-bombardment-mediated transformation, *Appl. Microbiol. Biotechnol.*, **36**, 228-230 (1991).

82. Serres, R., Stang, E., McCabe, D., Russell, D., Mahr, D., and McCown, B., Gene transfer using electric discharge particle bombardment and recovery of transformed cranberry plants, *J. Amer. Soc. Hort. Sci.*, **117**, 174-180 (1992).

*83. Shark, K. B., Smith, F. D., Harpending, P. R., Rasmussen, J. L., and Sanford, J. C., Biolistic transformation of a procaryote, *Bacillus megaterium*, *Appl. Environ. Microbiol.*, **57**, 480-485 (1991).

*84. Smith, F. D., Harpending, P. R., and Sanford, J. C., Biolistic transformation of prokaryotes - factors that affect transformation of very small cells, *J. Gen. Microbiol.*, **138**, 239-248, (1992).

*85. Somers, D.A., Rines, H. W., Gu, W., Kaeppler, H. F., and Bushnell, W. R., Fertile, transgenic oat plants, *Bio/Technol.*, **10**, 1589-1594, (1993).

*86. Stern, D. B. and Kindle, K. L., 3' end maturation of the *Chlamydomonas reinhardtii* chloroplast *atp*B mRNA is a two-step process, *Mol. Cell. Biol.*, **13**, 2277-2285 (1993).

*87. Stomp, A. M., Weissinger, A., and Sederoff, R. R., Transient expression from microprojectile-mediated DNA transfer in *Pinus taeda*, *Plant Cell Rep.*, **10**, 187-190 (1991).

*88. Svab, Z., Hajdukiewicz, P., and Maliga, P., Stable transformation of plastids in higher plants, *Proc. Natl. Acad. Sci. USA*, **87**, 8526-8530 (1990).

*89. Svab, Z. and Maliga, P., High-frequency plastid transformation in tobacco by selection for a chimeric *aad*A gene, *Proc. Natl. Acad. Sci. USA*, **90**, 913-917 (1993).

*90. Tang, D. C., Devit, M., Johnston, S. A., Genetic immunization is a simple method for eliciting an immune response, *Nature*, **356**:152-154, (1992).

*91. Taylor, M. G., and Vasil, I. K., Histology of, and physical factors affecting, transient GUS expression in pearl millet (*Pennisetum glaucum* (L.) R Br) embryos following microprojectile bombardment, *Plant Cell Rep.*, **10**, 120-125 (1991).

*92. Thorsness, P. E., and Fox, T. D., Escape of DNA from mitochondria to the nucleus in *Saccharomyces cerevisiae*, *Nature*, **346**, 376-379 (1990).

93. Titomirov, A. V., and Zelenin, A. V., New methods of transfection of mammalian cells: a minireview, *Molec. Biol.*, **359**, 1155-1159 (1989).

*94. Toffaletti, D. L., Rude, T. H., Johnston, S. A., Gene transfer in *Cryptococcus neoformans* by use of Biolistic delivery of DNA, *J . Bacteriol.*, **175**, 1405-1411 (1993).

*95. Tomes, D. T., Weissinger, A. K., Ross, M., Higgins, R., Drummond, B. J., Schaaf, S., Malone-Schoneberg, J., Staebell, M., Flynn, P., Anderson, J., and Howard, J., Transgenic tobacco plants and their progeny derived by microprojectile bombardment of tobacco leaves, *Plant Molec. Biol.*, **14**, 261-268 (1990).

*96. Twell, D., Klein, T. M., Fromm, M. E., and McCormick, S., Transient expression of chimeric genes delivered into pollen by microprojectile bombardment, *Plant Physiol.*, **91**, 1270-1274 (1989).

*97. Vasil, V., Brown, S. M., Re, D., Fromm, M. E., and Vasil, I. K., Stably transformed callus lines from microprojectile bombardment of cell suspension cultures of wheat, *Bio/Technol.*, **9**, 743-747 (1991).

*98. Vasil, V., Castillo, A. M., Fromm, M. E., and Vasil, I. K., Herbicide resistant fertile transgenic wheat plants obtained by microprojectile bombardment of regenerable embryogenic callus, *Bio/Technol.*, **10**, 667-674 (1992).

*99. Wang, Y. C., Cao, J., Sanford, J. C., and Wu, R., Transformation of rice, wheat and soybean by the microprojectile method, from *Symposium on the Molecular Basis of Plant Development, 17th Annual UCLA Symposia on Molecular & Cellular Biology*, March 26-April 2, 1988, *J. Cell Biochem. Suppl. 12*, Part C, p. 189 (1988).

*100. Wang, Y.-C., Klein, T. M., Fromm, M., Cao, J., Sanford, J. C., and Wu, R., Transient expression of foreign genes in rice, wheat and soybean cells following particle bombardment, *Plant Molec. Biol.*, **11**, 433-439 (1988).

*101. Weissinger, A., Tomes, D., Maddock, S., Fromm, M., and Sanford, J., Maize transformation via microprojectile bombardment, in *Molecular Biology: Genetic Improvements of Agriculturally Important Crops: Progress and Issues Meeting*, pp. 21-25, Cold Spring Harbor Laboratory, Cold Spring Harbor, New York (1988).

102. Wessler, S., and Hake, S., Maize harvest, *Plant Cell*, **2**, 495-499 (1990).

*103. Wilde, H. D., Meagher, R. B., and Merkle, S. A., Expression of foreign genes in transgenic yellow-poplar plants, *Plant Physiol.*, **98**, 114-120 (1992).

*104. Williams, R. S., Johnston, S. A., Riedy, M., DeVit, M. J., McElligott, S. G., and Sanford, J. C., Introduction of foreign genes into tissues of living mice by DNA-coated microprojectiles, *Proc. Natl. Acad. Sci. USA*, **88**, 2726-2730 (1991).

105. Wu, R., Transformation of rice and generation of transgenic rice plants, in *Proceedings of AgBiotech '89*, 190-192 (1989).

*106. Ye, G.-N., Daniell, H., and Sanford, J. C., Optimization of delivery of foreign DNA into higher-plant chloroplasts, *Plant Molec. Biol.*, **15**, 809-819 (1990).

107. Zelenin, A. V., Alimov, A. A., Barmintzev, V. A., Beniumov, A. O., Zelenina, I. A., Krasnov, A. M., and Kolesnikov, V. A., The delivery of foreign genes into fertilized fish eggs using high-velocity microprojectiles, *FEBS Lett.*, **287**, 118-120 (1991).

108. Zelenin, A. V., Alimov, A. A., Titomirov, A. V., Kazansky, A. V., Gorodetsky, S. I., and Kolesnikov, V.A., High-velocity mechanical DNA transfer of the chloramphenicolacetyl transferase gene into rodent liver, kidney and mammary gland cells in organ explants and in vivo, *FEBS Lett.*, **280**, 94-96 (1991).

109. Zelenin, A. V., Titomirov A. V., and Kolesnikov, V. A., Genetic transformation of mouse cultured cells with the help of high-velocity mechanical DNA injection, *FEBS Lett.*, **244**, 65-67 (1989).

110. Zumbrunn, G., Schneider, M., and Rochaix, J. D., A simple particle gun for DNA-mediated cell transformation, *Technique*, **1**, 204-216 (1989).

* Experiments performed with the Biolistic PDS-1000 technology.

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