

References

- Adams, DG (2000) Symbiotic interactions. In B. A. Whitton and M. Potts [eds.] *Ecology of cyanobacteria: their diversity in time and space* 523-561 Kluwer Academic, Dordrecht, Netherlands.
- Akopian, A. , He, J, Boocock, MR and Stark, WM (2003) Chimeric recombinases with designed DNA sequence recognition. *Proc. Natl. Acad. Sci. USA* 100: 8688-8691.
- Alfonso, M., Perewoska, I., and Kirilovsky, D. (2001) Redox Control of *ntcA* Gene Expression in *Synechocystis* sp. PCC 6803. Nitrogen Availability and Electron Transport Regulate the Levels of the NtcA Protein. *Plant Physiol.* 125: 969-981.
- Altling-Mees, MA, Sorge, JA, and Short, JM (1992) pBluescriptII: multifunctional cloning and mapping vectors. *Meth. Enzymol* 216: 483-495.
- Anton, T., and Schatz, DG (2000) Intermolecular V(D)J Recombination 275: 8341-8348.
- Apte, SK and Prabavathi, N. (1994) Rearrangement of nitrogen fixation genes (*nif*) in the heterocystous cyanobacteria. *J. Biosci.* 19: 579-602.
- Arcondéguy, T., Jack, R., and Merrick, M. (2001) P_{II} Signal Transduction Proteins, Pivotal Players in Microbial Nitrogen Control. *Microbiol. Mol. Biol. Rev.*, 2001: 65: 80-105.
- Bergman, B., Matveyev, A., Rasmussen, U. (1996) Chemical signalling in cyanobacterial-plant symbioses. *Trends in Plant Science* 1: 191-197.
- Biswas, I., Vagner, V and Ehrlich, SD (1992) Efficiency of homologous intermolecular recombination at different locations on the *Bacillus subtilis* chromosome. *J Bacteriol.* 174: 5593-5596.
- Black, TA and Wolk, CP (1994) Analysis of a Het- mutation in *Anabaena* sp. strain PCC 7120 implicates a secondary metabolite in the regulation of heterocyst spacing. *J.Bacteriol.* 176: 2282-2292.
- Bolivar, F., Rodriguez, RL, Greene, PJ, Betlach, MC, Heynecker, HL and Boyer, HW (1977) Construction and characterization of new cloning vehicles. II. A multipurpose cloning system. *Gene* 2: 95-113.
- Boyer, HW and Roulland-Dussoix, D. (1969) A complementation analysis of the restriction and modification of DNA in *Escherichia coli*. *J. Mol. Biol.* 41: 459-472.

- Bregu, M., Sherratt, DJ and Colloms, SD (2002) Accessory factors determine the order of strand exchange in Xer recombination at *psi*. *EMBO Journal* 21: 3888-3897.
- Brusca, JS, Hale, MA, Carrasco, CD and Golden, JW (1989) Excision of an 11-kilobase-pair DNA element from within the *nifD* gene in *Anabaena variabilis*. *J. Bacteriol.* 171:4138-4145
- Brusca, JS, Chastain, CJ and Golden, JW (1990) Expression of the *Anabaena* sp. strain PCC 7120 *xisA* gene from a heterologous promoter results in the excision of the *nifD* element. *J. Bacteriol.* 172: 3925-3931.
- Buchanan-Wallaston, J., Cannon, MC, Beynon, JL, and Cannon, FC (1981) Role of *nifA* gene product in the regulation of *nif* gene expression in *Klebsiella pneumoniae*. *Nature* 294: 776-778.
- Buikema, WJ and Haselkorn, R. (2001) Expression of the *Anabaena* *hetR* gene from a copper-regulated promoter leads to heterocyst differentiation under repressing conditions. *Proc. Natl. Acad. Sci. USA* 98: 2729-2734.
- Buikema, WJ, and Haselkorn, R. (1991) Characterization of a gene controlling heterocyst differentiation in the cyanobacterium *Anabaena* 7120. *Genes Dev* 5: 321-330.
- Callahan, SM and Buikema, WJ (2001) The role of HetN in maintenance of the heterocyst pattern in *Anabaena* sp. PCC 7120. *Mol. Microbiol.* 40: 941-950.
- Carlson, K, and Kosturko, LD (1998) Endonuclease II of coliphage T4: a recombinase disguised as a restriction endonuclease? *Mol. Microbiol.* 27: 671-676.
- Carrasco, CD, Buetlner, JA and Golden, JW (1995) Programmed DNA rearrangement of a cyanobacterial *hupL* gene in heterocysts. *Proc. Natl. Acad. Sci. USA* 92: 791-795.
- Carrasco, CD, Holliday, SD, Hansel, A, Lindbad, P and Golden, JW (2005) Heterocyst-Specific Excision of the *Anabaena* sp. Strain PCC 7120 *hupL* Element Requires *xisC*. *J. Bacteriol.* 187: 6031-6038.
- Carrasco, CD, Ramaswamy, KS, Ramasubramanian, TS and Golden, JW (1994) *Anabaena* *xisF* gene encodes a developmentally regulated site-specific recombinase. *Genes. Dev.* 8:74-83.
- Castenholz, RW and Waterbury, JB (1989) Preface. In: Staley JT, Bryant MP, Pfennig N, Holt JG, eds. *Bergey's Manual of Systematic Bacteriology, Volume 3*. Baltimore, MD, USA

- Chang, AC and Cohen, SN (1978) Construction and characterization of amplifiable multicopy DNA cloning vehicles derived from the P15A cryptic miniplasmid. *J. bacteriol.* 134: 1141-1156.
- Chen, JW , Evans, BR, Yang, SH, Teplow, DB and Jayaram, M (1991) Domain of a Yeast Site-Specific Recombinase (Flp) that Recognizes its Target Site *Proc. Natl. Acad. Sci. USA* 88: 5944-5948.
- Craig, NL, Craigie, R, Gellert, M, Lambowitz AM, eds. 2002. *Mobile DNA II*. Washington, DC: ASM Press.
- Degryse, E. (1996) In vivo intermolecular recombination in *Escherichia coli*: application to plasmid constructions. *Gene* 170:45-50
- Ehira, S, Ohmori, M and Sato N (2003) Genome-wide Expression Analysis of the Responses to Nitrogen Deprivation in the Heterocyst-forming Cyanobacterium *Anabaena* sp. Strain PCC 7120. *DNA Research* 10: 97-113.
- Ehira, S. and Ohmori, M. (2006) NrrA, a nitrogen-responsive response regulator facilitates heterocyst development in the cyanobacterium *Anabaena* sp. strain PCC 7120 *Mol. Microbiol.* 59: 1692-1703.
- El-Shehawy, R., Lugomela, C., Ernst A. and Bergman B. (2003) Diurnal expression of hetR and diazocyte development in the filamentous non-heterocystous cyanobacterium *Trichodesmium erythraeum*. *Microbiology* 149: 1139-1146.
- Esposito, D and Scocca, J (1997) The integrase family of tyrosine recombinases: evolution of a conserved active site domain. *Nucleic Acids Res.* 25: 3605-3614.
- Fay, P (1992) Oxygen relations of nitrogen fixation in cyanobacteria. *Microbiol. Reviews* 56: 340-373.
- Fiedler G., Arnold M., Hannus S. and Maldener I. (1998) The DevBCA exporter is essential for envelope formation in heterocysts of the cyanobacterium *Anabaena* sp. strain PCC 7120. *Mol. Microbiol.* 27: 1193-1202.
- Fischer, R., Tuli, R. and Haselkorn, R. (1981) A cloned cyanobacterial gene from glutamine synthetase functions in *E. coli* , but the enzyme is adenylated. *Proc. Natl. Acad. Sci. USA.* 78: 3393-3397.
- Flores, E., Muro-Pastor, AM, and Herrero. A. (1999) Cyanobacterial nitrogen assimilation genes and NtcA-dependent control of gene expression, p. 463-477.

- Forchhammer, K, and Tandeau de Marsac, N. (1995a) Functional analysis of the phosphoprotein P_{II} (*glnB* gene product) in the cyanobacterium *Synechococcus* sp. strain PCC 7942. *J. Bacteriol.* 177: 2033-2040.
- Forchhammer, K. (2004) Global carbon/nitrogen control by PII signal transduction protein in cyanobacteria: from signals to targets. *FEMS Microbiol.* 28: 319-333.
- Frías, JE, Flores, E, Herrero, A (1994) Requirement of the regulatory protein NtcA for the expression of nitrogen assimilation and heterocyst development genes in the cyanobacterium *Anabaena* sp. PCC 7120. *Mol. Microbiol.* 14: 823-832.
- Frías, JE, Flores, E, and Herrero, A (2000) Activation of the *Anabaena nir* operon promoter requires both NtcA (CAP family) and NtcB (LysR family) transcription factors. *Mol. Microbiol.* 38:613-625.
- Frías, JE, Flores, E., and Herrero, A (1997) Nitrate assimilation gene cluster from the heterocyst-forming cyanobacterium *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 179: 477-486.
- García-Domínguez, M., and Florencio, FJ (1997) Nitrogen availability and electron transport control the expression of *glnB* gene (encoding P_{II} protein) in the cyanobacterium *Synechocystis* sp. PCC 6803. *Plant Mol. Biol.* 35: 723-734.
- Golden, JW and Weist, D (1988) Genome rearrangement and nitrogen fixation in *Anabaena* blocked by inactivation of XisA gene. *Science* 242: 1421-1423.
- Golden, JW and Yoon HS (2003) Heterocyst development in *Anabaena*. *Curr. Opin. Microbiol.* 6: 557-563.
- Golden, JW, Mulligan, M and Haselkorn, R (1987) Different recombination site specificity of two developmentally regulated genome rearrangements. *Nature* 327:52-29.
- Grindley, NDF, Whiteson, KL and Rice PA (2006) Mechanisms of Site-Specific Recombination. *Annu. Rev. Biochem.* 2006. 75: 567-605.
- Hanahan, D (1985) Studies on transformation of *E. coli* with plasmids. *J. Mol. Biol.* 166: 557-580.
- Harano, Y., Suzuki, I., Maeda, SI, Kaneko, T., Tabata, S. and Omata, T. (1997) Identification and nitrogen regulation of the cyanase gene from the cyanobacteria *Synechocystis* sp. strain PCC 6803 and *Synechococcus* sp. strain PCC 7942. *J. Bacteriol.* 179: 5744-5750.

Haselkorn, R (1993) Excision of elements interrupting nitrogen-fixation operon in cyanobacteria, In" *Mobile DNA*" American Society of Microbiology.

Haselkorn, R (1992) Developmentally regulated gene rearrangements in prokaryotes. *Ann. Rev. Genet.* 26: 113-130.

Henson BJ, Watson LE, Barnum SR (2005) Characterization of a 4 kb Variant of the *nifD* element in *Anabaena* sp. Strain ATCC 33047. *Curr. Microbiol.* 50: 129-132.

Herrero, A., Muro-Pastor, AM and Flores E (2001) Nitrogen Control in Cyanobacteria. *J Bacteriol* 183: 411-425.

Herrero, A., Muro-Pastor, AM, Valladares, A. and Flores E. (2004) Cellular differentiation and the NtcA transcription factor in filamentous cyanobacteria. *FEMS Microbiol. Rev.* 28: 469-487.

Huang, X., Dong, Y., and Zhao, J. (2004) HetR homodimer is a DNA-binding protein required for heterocyst differentiation, and the DNA-binding activity is inhibited by PatS. *Proc. Natl. Acad. Sci. USA* 101: 4848-4853.

Jaggi, R., Van Heeswijk, WC, Westerhoff, HV, Ollis DL and Vasudevan SG (1997) The two opposing activities of adenylyl transferase reside in distinct homologous domains, with intramolecular signal transduction. *The EMBO Journal* 16: 5562-5571.

Jessop, L, Bankhead, T, Wong, D and Segall AM (2000) The Amino Terminus of Bacteriophage λ Integrase Is Involved in Protein-Protein Interactions during Recombination. *J. bacterial.* 182: 1024-1034.

Jiang, F, Wisen, S, Widersten, M, Bergman, B and Mannervik, B (2000) Examination of the transcription factor NtcA-binding motif by *in vitro* selection of DNA sequences from a random library. *J. Mol. Biol.* 301: 783-793.

Jo, K and Topal, MD (1995) DNA topoisomerase and recombinase activities in NaeI restriction endonuclease. *Science* 267: 1817-1820.

Jones KM, Buikema WJ, Haselkorn R. (2003) Heterocyst-specific expression of *patB*, a gene required for nitrogen fixation in *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 185: 2306-2314.

Kaneko, T, Nakamura, Y and Wolk, CP (2001) Complete genomic sequence of filamentous nitrogen-fixing cyanobacterium *Anabaena* sp. strain PCC 7120. *DNA Research* 8: 205-213.

Karunakaran, R. (2000) Mechanism of excision of *nifD* element of heterocystous cyanobacteria *Anabaena* sp. strain PCC 7120 in *Escherichia coli*. PhD thesis, M. S. University of Baroda, Department of Biochemistry.

Kazmierczak, RA, Swalla, BM., Burgin AB, Gumpert, RI, and Gardner JF (2002) Regulation of site-specific recombination by the C-terminus of λ integrase. *Nucleic Acids Res.* 30: 5193- 5204.

Khudyakov, I and Wolk, CP (1997) *hetC*, a gene coding for a protein similar to bacterial ABC protein exporters, is involved in early regulation of heterocyst differentiation in *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 179: 6971-6978.

Khudyakov, IY, and Golden, JW (2004) Different functions of HetR, a master regulator of heterocyst differentiation in *Anabaena* sp. PCC 7120, can be separated by mutation. *Proc. Natl. Acad. Sci. USA* 101: 16040-16045.

Kolb A., Busby, S., Buc, H., Garges, S., Adhya, S. (1993) Transcriptional regulation by cAMP and its receptor protein. *Annu. Rev. Biochem.* 62:749-795.

Kuhn I., Peng L., Bedu S. and Zhang, CC (2000) Developmental regulation of the cell division protein FtsZ in *Anabaena* sp. strain PCC 7120, a cyanobacterium capable of terminal differentiation. *J. Bacteriol.* 182, 4640-4643.

Lammers, P, Golden, JW and Haselkorn, R (1986) Identification and sequence of a gene required for a developmentally regulated DNA excision in *Anabaena*. *Cell* 44: 905-911.

Laurent, S., Chen, H., Bédu, S., Ziarelli, F., Peng, L., and Zhang, CC. (2005) Nonmetabolizable analogue of 2-oxoglutarate elicits heterocyst differentiation under repressive conditions in *Anabaena* sp. strain PCC 7120. *Proc Natl Acad Sci USA* 102: 9907-9912.

Li, B., Huang, X., and Zhao, J. (2002) Expression of *hetN* during heterocyst differentiation and its inhibition of *hetR* up-regulation in the cyanobacterium *Anabaena* sp. PCC 7120. *FEBS. Lett.* 517: 87-91.

Li, JH, Laurent, S., Konde, V., Bedu, S. and Zhang, C.-C. (2003) An increase in the level of 2-oxoglutarate promotes heterocyst development in the cyanobacterium *Anabaena* sp. strain PCC 7120 *Microbiology* 149: 3257-3263.

Liang J, Scappino L, Haselkorn R. (1993) The *patB* gene product, required for growth of the cyanobacterium *Anabaena* sp. strain PCC 7120 under nitrogen-limiting conditions, contains ferredoxin and helix-turn-helix domains. *J. Bacteriol.* 175:1697-1704.

Liang, J., Scappino, L., and Haselkorn, R. (1992) The *patA* gene product, which contains a region similar to CheY of *Escherichia coli*, controls heterocyst pattern formation in *Anabaena* sp. strain PCC 7120. *Proc. Natl. Acad. Sci. USA* 89: 5655-5659.

Liu, D and Golden, JW (2002) *hetL* over-expression stimulates heterocyst formation in *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 184: 6873-6881.

Luque, I., Felix, M., Bermudez, V, Paz-Yepes, J. Flores, E. and Herrero, A. (2004) In vivo activity of the nitrogen control transcription factor NtcA is subjected to metabolic regulation in *Synechococcus* sp. Strain PCC 7942 *FEMS Microbiol Lett.* 236: 47-52.

Luque, I.E, Flores, E. and Herrero, A. (1994) Molecular mechanism for the operation of nitrogen control in cyanobacteria. *EMBO J.* 13:2862-2869

MacWfams, MP, Gumport, RI and Garher, JF (1996) Genetic analysis of the bacteriophage A *attL* nucleoprotein complex. *Genetics* 143: 1069-1079.

Maeda, SI., Kawaguchi, Y., Ohe TA, and Omata, T. (1998) *cis*-acting sequences required for NtcB-dependent, nitrite-responsive positive regulation of the nitrate assimilation operon in the cyanobacterium *Synechococcus* sp. strain PCC 7942. *J. Bacteriol.* 180:4080-4088.

Mead, DA, Szczesna-Skorupa E and Kemper, B. (1986) Single-stranded DNA áblue' T7 promoter plasmids: a versatile tandem promoter system for cloning and protein engineering. *Protein. Eng.* 1: 67-74.

Meeks, JC (1998) Symbiosis between nitrogen fixing cyanobacteria and plants. *BioScience* 48: 266-276.

Meeks, JC, Campbell, EL, Hagen, K., Hanson, T., Hitzeman, N and Wong, F (1999) Developmental alternatives of symbiotic *Nostoc punctiforme* in response to its plant partner *Anthoceros punctatus*. In: The Phototrophic Prokaryotes (G.A. Peschek, W. Löffelhardt and G. Schmetterer, eds.). pp. 665-678, Plenum Publishing Corp., New York.

Meeks, JC and Elhai J (2002) Regulation of Cellular Differentiation in Filamentous Cyanobacteria in Free-Living and Plant-Associated Symbiotic Growth States. *Microbiol. Mol. Biol. Rev.* 66: 94-121.

Meeks, JC, Elhai, J., Thiel, T., Potts, M., Larimer, F., Lamerdin, J *et al.* (2001) An overview of the genome of *Nostoc punctiforme*, a multicellular, symbiotic cyanobacterium. *Photosynth. Res.* 70: 85-106.

Merida A., Candau, P. and Florencio, FJ (1991a) Regulation of glutamine synthetase activity in the unicellular cyanobacterium *Synechocystis* sp. PCC 6803 by the nitrogen source: effect of ammonium. *J. Bacteriol.*, 173: 4095-4100.

Merida, A., Candau, P. and Florencio, FJ (1991b) *In vitro* reactivation of *in vivo* ammonium inactivated glutamine synthetase from *Synechocystis* sp. PCC 6803. *Biochem. Biophys. Res. Comm.* 181: 780-786.

Merida, A., Leurentop, L., Candau, P. and Florencio, FJ (1990) Purification and properties of glutamine synthetase from the cyanobacteria *Synechococcus* PCC 6803 and *Calothrix* PCC 7601. *J. Bacteriol.* 172: 4732-4735.

Mishra, HS and Tuli, R (2000) Differential Expression of Photosynthesis and Nitrogen Fixation Genes in the Cyanobacterium *Plectonema boryanum*. *Plant Physiol.* 122: 731-736.

Montesinos, ML, Muro-Pastor AM, Herrero, A. and Flores, E. (1998) Ammonium/ methylammonium permeases of a cyanobacterium. Identification and analysis of three nitrogen-regulated *amt* genes in *Synechocystis* sp. PCC 6803. *J. Biol. Chem.* 273: 31463-31470.

Morett, E and Buck, M (1988) NifA-dependent *in vivo* protection demonstrates that the upstream activator sequence of *nif* promoters is a protein binding site. *Proc. Natl. Acad. Sci. USA* 85: 9401-9405.

Morris, CE, Klement, JF and McAllister WT (1986) Cloning and expression of the bacteriophage T3 RNA polymerase gene. *Gene* 41: 193-200.

Mucke, M, Grelle, G, Behlke, J, Kraft, R, Kruger, DH, and Reuter, M (2002) EcoRII: a restriction enzyme evolving recombination functions?. *EMBO J* 21:5262-5268.

Mucke, M, Kruger, DH and Reuter, M (2003) Diversity of Type II restriction endonucleases that require two DNA recognition sites. *Nucleic Acids Res.* 21: 6079-6084.

Mucke, M., Kruger DH and Reuter M (2003) Diversity of type II restriction endonucleases that require two DNA recognition sites. *Nucleic Acids Res.* 31: 6079-6084.

Mulligan, ME, Haselkorn, R (1989) Nitrogen-fixation (*nif*) genes of the cyanobacterium *Anabaena* sp. strain PCC 7120: The *nifBfdxN-nifS-nifU* operon. *J. Biol. Chem.* 264: 19200-19207.

Muro-Pastor, AM, Valladares, A., Flores, E. and Herrero, A. (2002) Mutual dependence of the expression of the cell differentiation regulatory protein HetR and the global nitrogen regulator NtcA during heterocyst development. *Mol Microbiol* 44, 1377-1385.

Muro-Pastor, MI, Reyes JC and Florencio FJ (1996) The NADP⁺-isocitrate dehydrogenase gene (*icd*) is nitrogen regulated in cyanobacteria. *J. Bacteriol.* 178: 4070-4076.

Muro-Pastor, MI, Reyes, JC and Florencio, FJ (2001) Cyanobacteria perceive nitrogen status by sensing intracellular 2-oxoglutarate levels. *J Biol Chem* 276, 38320-38328.

Murry MA and Wolk CP (1989) Evidence that the barrier to the penetration of oxygen into heterocysts depends upon two layers of the cell envelope. *Arch of Microbiol.* 151: 469-474.

Muth, G, Nussbaumer B, Wohlleben, W and Pühler, A (1989) A vector system with temperature-sensitive replication for gene disruption and mutational cloning in *streptomyces*. *Mol. Gen. Genet.* 219: 341-348.

Nash, H.A. (1996) Site-specific recombination: integration, excision, resolution, and inversion of defined DNA segments. In: *Escherichia coli and Salmonella typhimurium: Cellular and Molecular Biology* (Neidhart, F.C. et al., Eds.), 2nd edn., Vol.2, pp. 2363-2376. American Society for Microbiology, Washington, DC.

Nierzwicki-Bauer SA, Balkwill, DL and Stevens Jr. SE (1984) Heterocyst differentiation in the cyanobacterium *Mastigocladus laminosus*. *J. Bacteriol.* 157: 514-525.

Nunes-Duby, S.E., Azaro, M.A. and Landy, A. (1995) Swapping DNA strands and sensing homology without branch migration in lambda site-specific recombination. *Curr. Biol.* 5: 139-148.

Nunes-Duby, SE, Kwon, HJ, Tirumalai, RS, Ellenberger, T and Landy A (1998) Similarities and differences among 105 members of the *Int* family of site-specific recombinases. *Nucleic Acids Res.* 26: 391-406.

Olmedo-Verd, E., Flores, E., Herrero A. & Muro-Pastor, A. M. (2005) HetR-Dependent and Independent Expression of Heterocyst-Related Genes in an *Anabaena* Strain Overproducing the NtcA Transcription Factor. *J. Bacteriol.* 187: 1985-1991.

Ramasubramanian, TS, Wei, TF., Oldham, AK and Golden, JW (1996) Transcription of the *Anabaena* sp. strain PCC 7120 *ntcA* gene: multiple transcripts and NtcA binding. *J. Bacteriol.* 178:922-926.

Schopf, JW (1994) Disparate rates, differing fates: tempo and mode of evolution changed from the Precambrian to the Phanerozoic. *Proc Natl Acad Sci USA* 91: 6735-6742.

Schopf, JW (1996) Are the oldest fossils cyanobacteria? In: Roberts DM, Sharp P, Alderson G, Collins M, ed. *Evolution of Microbial Life*. Cambridge, UK: Cambridge University Press, 23-61.

Ramaswamy, KS, Carrasco, CD, Fatma, T & Golden, J W (1997) Cell-type specificity of the *Anabaena* fdxN-element rearrangement requires xisH and xisI. *Mol Microbiol.* 1241-1250.

Sherman DM, Tucker D and Sherman LA (2000) Heterocyst development and localization of cyanophycin in N₂-fixing cultures of *Anabaena* sp. PCC 7120 (cyanobacteria). *J. Phycol.* 36: 932-941.

Smith MC and Thorpe HM (2002) Diversity in serine recombinases. *Mol. Microbiol.* 44:299-307

Spanopoulou, E, Zaitseva, F, Wang, F, Santagata S, Baltimore D and Panayotou G. (1996) The Homeodomain Region of Rag-1 Reveals the Parallel Mechanisms of Bacterial and V(D)J Recombination. *Cell* 87: 63-276.

Stahl, L. (2003) Smart modelling of unusual cyanobacteria - an enigma solved? *New Phytologist* 160: 455-457.

Stanier, G (1988) Fine structure of cyanobacteria. In: Packer L, Glazer AN, eds. *Methods in enzymology*, Vol. 167. London, UK: Academic Press, 157-172.

Stanier, RY and Cohen-Bazire, G. (1977) Phototrophic prokaryotes: the cyanobacteria. *Annu Rev Microbiol* 31, 225-274.

Stark, MJR (1987) Multicopy expression vectors carrying the *lac* repressor gene for regulated high-level expression of genes in *Escherichia coli*. *Gene* 51: 255-267.

Stock JB, Ninfa AJ and Stock AM (1989) Protein phosphorylation and regulation of adaptive responses in bacteria. *Microbiol. Rev.*, 53: 450-490.

Stragier, P, Kunkel, B, Kroos, L and Losick R (1989) Chromosomal rearrangement generating a composite gene for a developmental transcription factor. *Science* 243: 507-512.

Tamagnini P., Axelsson R., Lindberg, P., Oxelfelt F., Wünschiers R. and Lindblad P. (2002) Hydrogenases and Hydrogen Metabolism of Cyanobacteria. *Microbiol. Mol. Biol. Rev.*, 66: 1 - 20.

Tanigawa, R., Shirokane, M., Maeda, S. I., Omata, T., Tanaka, K. and Takahashi, H. (2002) Transcriptional activation of NtcA-dependent promoters of *Synechococcus* sp. PCC 7942 by 2-oxoglutarate *in vitro*. *Proc. Natl. Acad. Sci. USA* 99: 4251-4255.

Tirumalai, RS, Healey, E and Landy, A (1997) The catalytic domain of lambda site-specific recombinase. *Proc. Natl. Acad. Sci. USA* 94:6104-6109.

Topal, MD and Conrad M (1993) Changing endonuclease EcoRII Tyr308 to Phe abolishes cleavage but not recognition: possible homology with the Int-family of recombinases. *Nucleic Acids Res.* 21: 2599-2603.

- Torrecilla, I., Leganés, F., Bonilla, I., and Fernández-Piñas, F. (2004) A calcium signal is involved in heterocyst differentiation in the cyanobacterium *Anabaena* sp. PCC7120.
- Van den Broek, B, Vanzi, F, Normanno, D, Pavone, FS, and Wuite, GJL (2006) Real-time observation of DNA looping dynamics of Type IIE restriction enzymes NaeI and NarI. *Nucleic Acids Res.* 34: 167-174.
- Vazquez-Bermudez, MF, Herrero, A. and Flores, E. (2002) Carbon supply and 2-oxoglutarate elects on expression of nitrate reductase and nitrogen-regulated genes in *Synechococcus* sp. strain PCC 7942 *FEBS Lett.* 512:71-74.
- Walsby, AE (1985) The permeability of heterocysts to the gases nitrogen and oxygen. *Proceedings of the Royal Society of London, Series B*, 226: 345-366.
- Weckesser, J and Jurgens, UJ (1988) Cell walls and external layers. In: Packer L, Glazer AN, eds. *Methods in Enzymology*, Vol. 167. London, UK: Academic Press, 173-188.
- Wei, TF, Ramasubramanian, TS, Golden, JW (1994) *Anabaena* sp. strain PCC 7120 *ntcA* gene required for growth on nitrate and heterocyst development. *J Bacteriol.* 176 :4473-4482.
- Wei, TF, Ramasubramanian, TS, Pu, F, and Golden JW (1993) *Anabaena* sp. strain PCC 7120 *bifA* gene encoding a sequence-specific DNA-binding protein cloned by in vivo transcriptional interference selection. *J Bacteriol.* 175 :4025-4035.
- Wolk CP, Ernst A. and Elhai J. (1994) Heterocyst metabolism and development. In: The Molecular Biology of Cyanobacteria (Bryant, D.A., Ed.), pp. 769-823. Kluwer Academic Publishers, The Netherlands.
- Wolk CP (2000) Heterocyst formation in *Anabaena*. In *Prokaryotic Development*. Brun, Y.V., and Shimkets, L.J. (eds). Washington, DC: American Society for Microbiology, pp. 83-104.
- Wong, FC and Meeks, JC (2001) The *hetF* gene product is essential to heterocyst differentiation and affects HetR function in the cyanobacterium *Nostoc punctiforme*. *J. Bacteriol.* 183: 2654-2661.
- Wu, X., Liu, D., Lee, MH, and Golden, JW (2004) *patS* minigenes inhibit heterocyst development of *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 186: 6422-6429.
- Yanisch-Perron, C., Vierra, J and Messing, J (1985) Improved M13 phage vectors and host strains: Nucleotide sequence of the M13mp18 and pUC19 vectors. *Gene* 33: 103-119.

Yoon, HS, and Golden, JW (2001) PatS and products of nitrogen fixation control heterocyst pattern. *J. Bacteriol.* 183: 2605–2613.

Zhao, Y., Shi, Y., Zhao, W., Huang, X., Wang, D., Brown, N., *et al.* (2005) CcbP, a calcium-binding protein from *Anabaena* sp. PCC 7120, provides evidence that calcium ions regulate heterocyst differentiation. *Proc. Natl. Acad. Sci. USA* 102: 5744–5748.

Zhou, R and Wolk CP (2003) A two-component system mediates developmental regulation of biosynthesis of a heterocyst polysaccharide. *J. Biol. Chem.* 278:19939–19946.

Zhou, R., Wei, X., Jiang, N., Li, H., Dong, Y., Hsi, K.L., and Zhao, J. (1998) Evidence that HetR protein is an unusual serine-type protease. *Proc. Natl. Acad. Sci. USA* 95: 4959–4563.

Zhu J, Jager K., Black T., Zarka K., Koksharova, O. and Wolk, C.P. (2001) HcwA, an autolysin, is required for heterocyst maturation in *Anabaena* sp. strain PCC 7120. *J. Bacteriol.* 183, 6841–6851.

Zhu, J., Kong, R., Wolk, CP (1998) Regulation of *hepA* of *Anabaena* sp. strain PCC 7120 by elements 5' from the gene and by *hepK*. *J. Bacteriol.* 180:4233–4242.