



## Catalog of Innovations. 2016

- Nucleic acid analogs
- Synthetic Biology
- Diagnostics
- DNA sequencing
- Bioinformatics
- SNP detection
- Polymerases

# Index

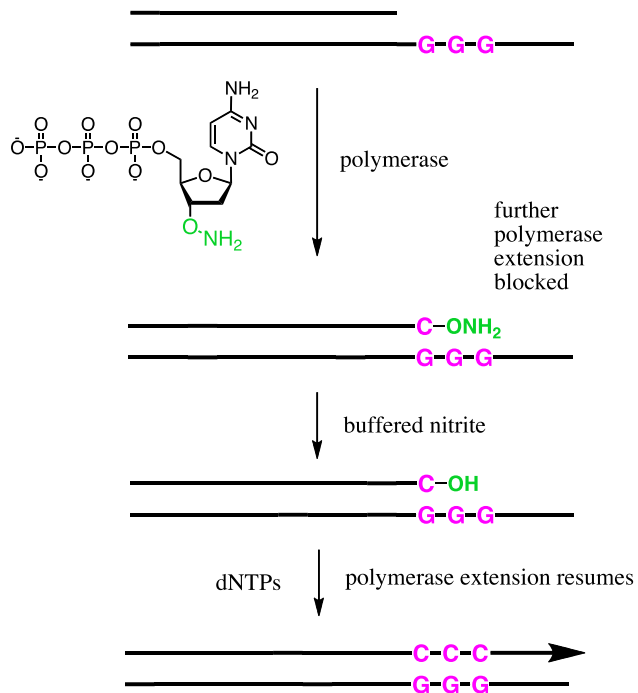
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# Reversible terminators in primer extension

Firebird has introduced the 3'-ONH<sub>2</sub> reversible terminator to replace bulky 3'-OCH<sub>2</sub>N<sub>3</sub> groups, as well as their problematic enzymology and cleavage.

## How do they work?

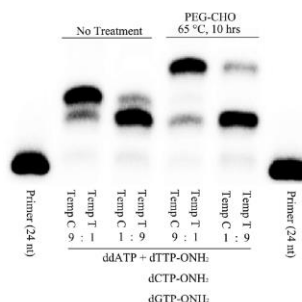
The 3'-ONH<sub>2</sub> group is accepted by Firebird proprietary polymerases, and blocks further primer extension. It is cleaved in seconds in buffered aqueous sodium nitrite.



## What are they used for?

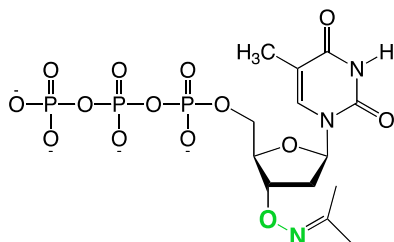
FfAME architectures use this terminator in SNP analysis and sequencing, for example.

Polymorphisms (SNPs) are detected with low background by competing Firebird reversible terminators with irreversible terminators, even when non-SNPed DNA is present in abundance.

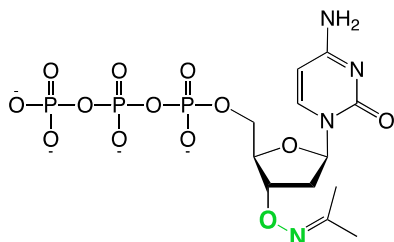


# Oxime blocked untagged reversible terminators

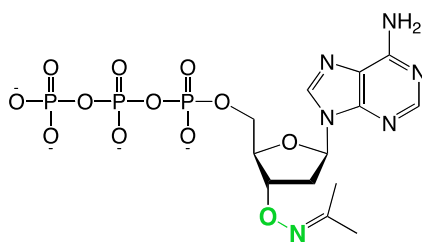
Triphosphates carrying the 3'-ONH<sub>2</sub> reversible terminator are prepared as acetone oximes, which are stable indefinitely. The oxime is deprotected in seconds *in situ* with dilute buffered hydroxylamine before use.



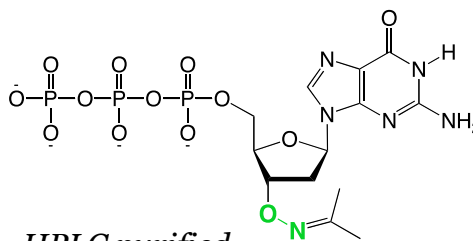
Thymine  
TONH<sub>2</sub>-DH101  
5 μmoles \$ 600.00  
Bulk inquire



Cytosine  
CONH<sub>2</sub>-MK102  
5 μmoles \$ 750.00  
Bulk inquire



Adenine  
AONH<sub>2</sub>-DH103  
5 μmoles \$ 750.00  
Bulk inquire



Guanine  
GONH<sub>2</sub>-DH104  
5 μmoles \$ 750.00  
Bulk inquire

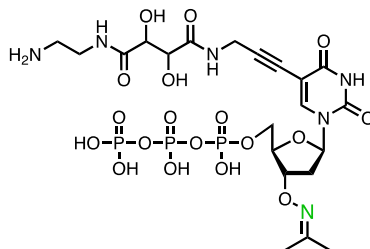
*HPLC purified*

**Polymerase variants** have been developed that incorporate these with improved efficiency over standard Taq DNA polymerase

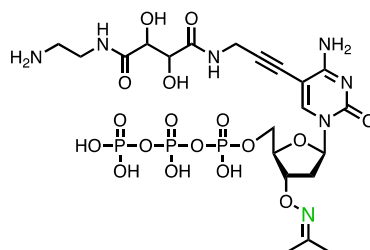
Polymerase 475	400 units	\$110.00
POL475-NL201	1000 units	280.00

# Reversible terminators with diol-linked tags

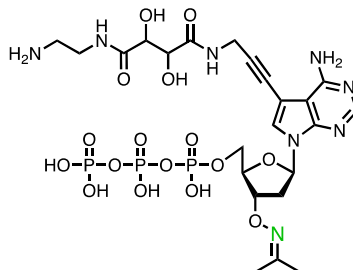
For sequencing research, Firebird offers triphosphates with a 3'  $-ONH_2$  reversible terminator and a diol linker carrying a free amino group, to which can be attached a fluor or other signaling moiety. . The diol is cleaved in seconds by aqueous periodate.



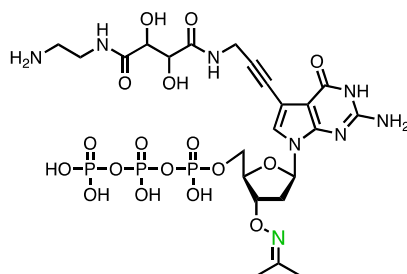
Thymine  
TONH2DT-DH429  
1  $\mu$ mole \$1750.00  
Bulk inquire



Cytosine  
CONH2DT-MK001  
1  $\mu$ mole \$1900.00  
Bulk inquire



Adenine  
AONH2DT-DH545  
1  $\mu$ mole \$2200.00  
Bulk inquire



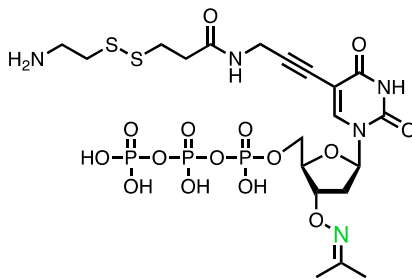
Guanine  
GONH2DT-DH475  
1  $\mu$ mole \$2300.00  
Bulk inquire

The  $-ONH_2$  is protected as its oxime, to allow customers to add (if they desire, for research purposes) fluorescent reporters of their own choice. The oxime is deprotected with dilute buffered hydroxylamine to give free  $-ONH_2$ .

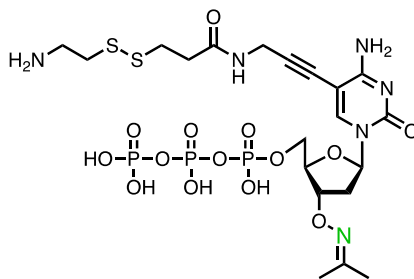
*Note: Not available for sequencing applications on certain machines and in certain jurisdictions. Please inquire.*

# Reversible terminators with disulfide-linked tags

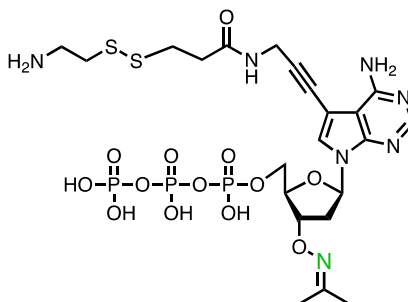
For sequencing research, Firebird also offers triphosphates with a 3'  $-ONH_2$  reversible terminator and a conventional disulfide-containing linker carrying a free amino group, to which can be attached a fluor or other signaling moiety.



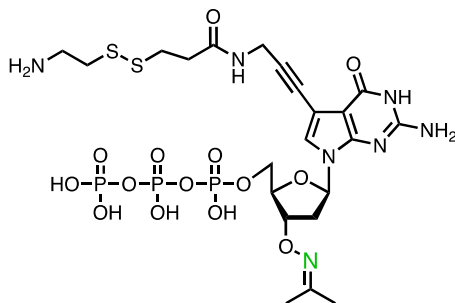
Thymine  
TONH2ST-DH491  
1  $\mu$ mole \$1750.00  
Bulk: inquire



Cytosine  
CONH2ST-MK702  
1  $\mu$ mole \$2000.00  
inquire



Adenine  
AONH2ST-DH703  
1  $\mu$ mole \$2400.00  
Bulk inquire



Guanine  
GONH2ST-DH704  
1  $\mu$ mole \$2500.00  
Bulk inquire

The  $-ONH_2$  is protected as its oxime, to allow customers to add (if they desire, for research purposes) fluorescent reporters of their own choice. The oxime is deprotected with dilute buffered hydroxylamine to give free  $-ONH_2$ .

*Note: Not available for sequencing applications on certain machines and in certain jurisdictions. Please inquire.*

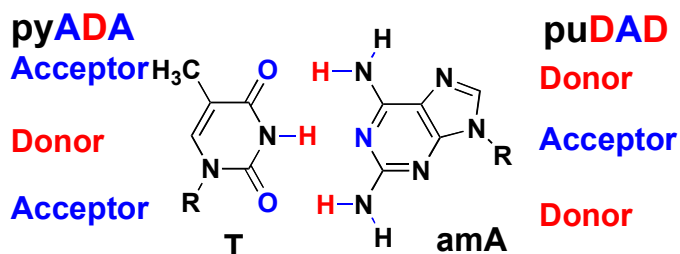
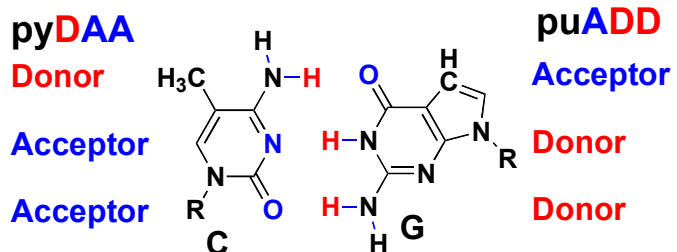
# Achieving orthogonality

## Artificially Expanded Genetic Information Systems (AEGIS)<sup>TM</sup>

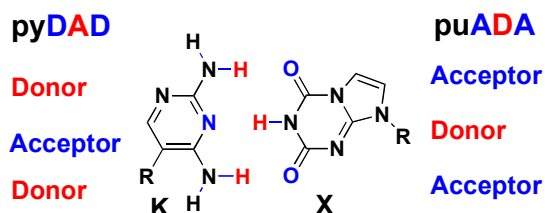
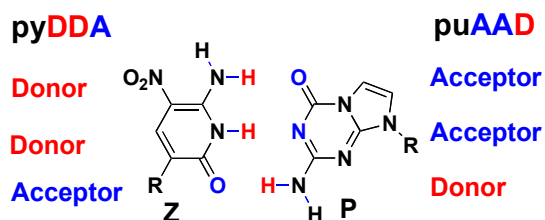
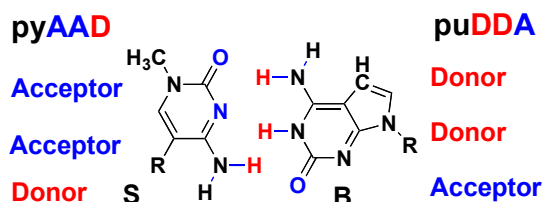
### The concept

When detecting DNA in complex biological media, uninteresting DNA can interfere.

In 1990, innovators at **Firebird** solved this problem, developing an Artificially Expanded Genetic Information System (AEGIS)<sup>TM</sup>.



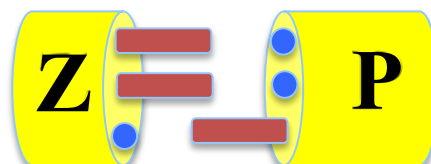
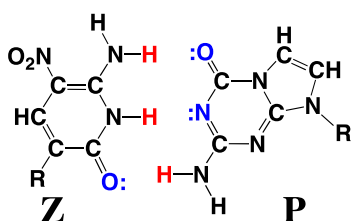
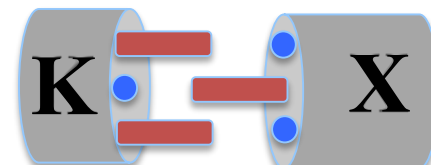
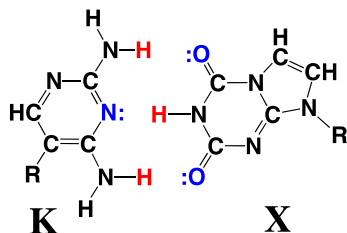
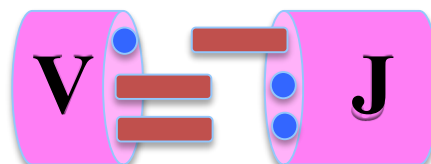
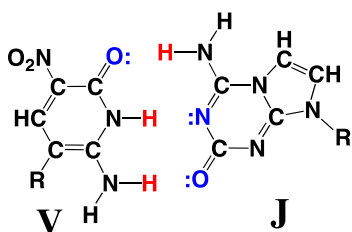
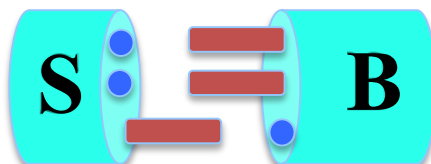
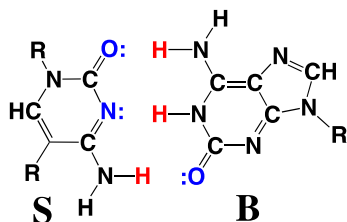
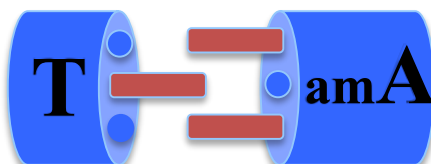
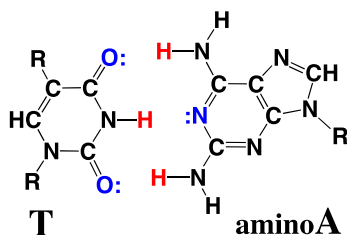
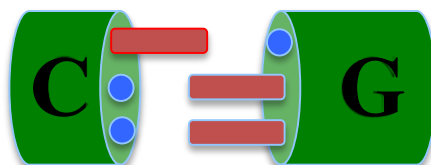
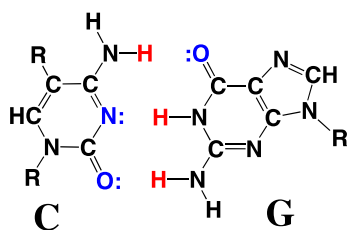
By shuffling hydrogen bond **donors** and **acceptors**, the Z:P, K:X. and S:B pairs were created.



# Artificially Expanded Genetic Information Systems

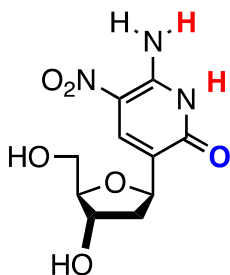
(AEGIS)<sup>TM</sup>

The complete AEGIS expanded alphabet. Different heterocycles implement the various AEGIS hydrogen bonding patterns. Shown are our most popular heterocycles.

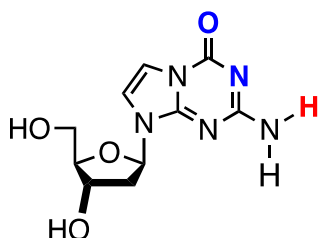




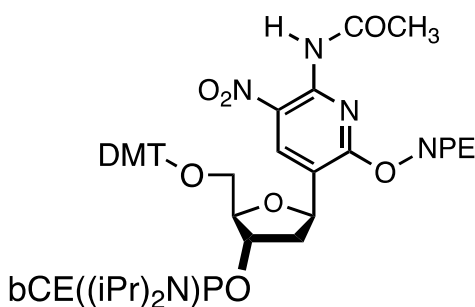
# Artificially Expanded Genetic Information Systems dZ:dP system. Nucleosides & phosphoramidites



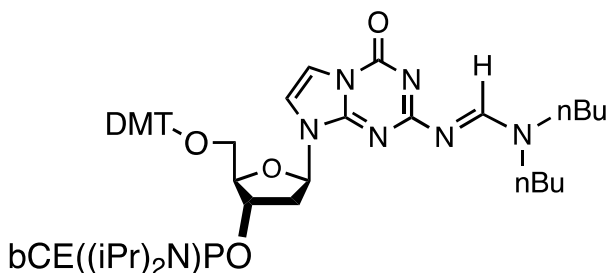
Hydrogen bonding pattern: Z  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Nitropyridine  
 Derivative: Free nucleoside  
 Cat. No. ZdNF-05010201  
 100 mg \$340.00  
 1 gram \$2720.00  
 Bulk inquire



Hydrogen bonding pattern: P  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Imidazotriazine  
 Derivative: Free nucleoside  
 Cat. No. PdNF-06010601  
 100 mg \$370.00  
 1 gram \$2960.00  
 Bulk inquire



Hydrogen bonding pattern: Z  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Nitropyridine  
 Derivative: Phosphoramidite  
 Cat. No. ZdNP-05010203  
 100 mg \$ 720.00  
 1 gram \$5760.00  
 Bulk inquire

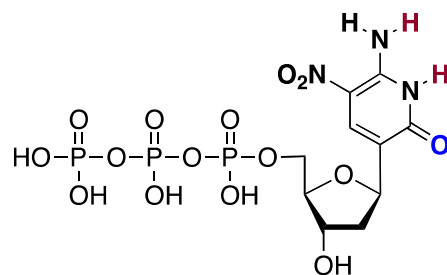


Hydrogen bonding pattern: P  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Imidazotriazine  
 Derivative: Phosphoramidite  
 Cat. No. PdNP-06010603  
 100 mg \$ 850.00  
 1 gram \$6800.00  
 Bulk inquire

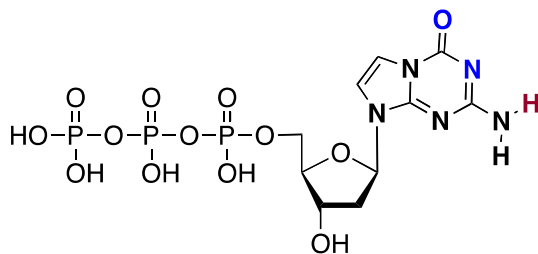
*Oligonucleotides are available that incorporate dZ and dP.  
 Ribonucleoside derivatives are also available. Please inquire.*

# Artificially Expanded Genetic Information Systems

## The dZ:dP system: Triphosphates and polymerases



Hydrogen bonding pattern: Z  
Sugar: 2'-deoxyribose  
Heterocycle: Imidazotriazine  
Derivative: Triphosphate  
Cat. No. PdNT-05010204  
1  $\mu$ mole \$ 400.00  
5  $\mu$ moles \$ 1600.00  
Bulk inquire



Hydrogen bonding pattern: P  
Sugar: 2'-deoxyribose  
Heterocycle: Imidazotriazine  
Derivative: Triphosphate  
Cat. No. PdNT-06010604  
1  $\mu$ mole \$ 420.00  
5  $\mu$ moles \$ 1680.00  
Bulk inquire

*These are fifth and sixth letters of a DNA alphabet that are used in priming, primer extension, and PCR.*

**Firebird** innovators have developed and tested polymerases to incorporate dZ opposite dP and dP opposite dZ.

ZiP Polymerase	400 units	\$300.00
ZiPOL475-ZY201	1000 units	\$500.00

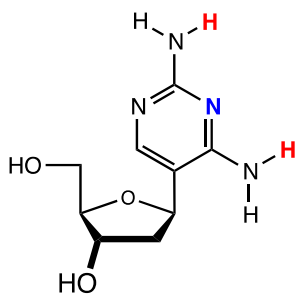
Ribonucleoside triphosphates and supporting RNA polymerases are also available. *Please inquire.*



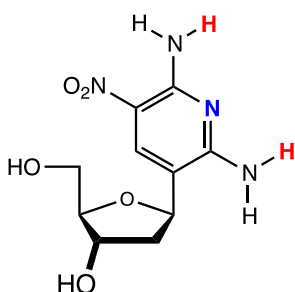
# Artificially Expanded Genetic Information Systems

## The dK:dX system. Nucleosides

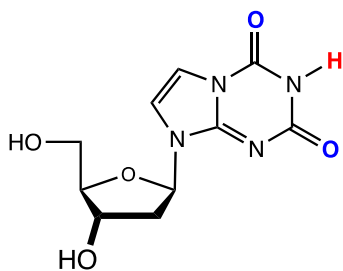
Multiple heterocycles implement the dK and dX hydrogen bonding patterns. Two each are offered as nucleosides, phosphoramidites, & triphosphates.



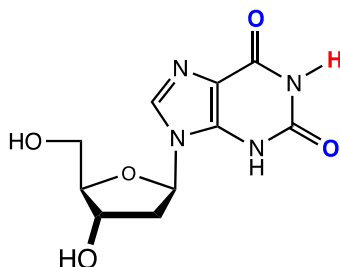
Hydrogen bonding pattern: K  
Sugar: 2'-deoxyribose  
Heterocycle: Pyrimidine  
Derivative: Free nucleoside  
Cat. No. KdYF-07010101  
100 mg \$ 380.00  
1 gram \$ 3040.00  
Bulk inquire



Hydrogen bonding pattern: K  
Sugar: 2'-deoxyribose  
Heterocycle: Nitropyridine  
Derivative: Free nucleoside  
Cat. No. KdPF-07010201  
100 mg \$ 360.00  
1 gram \$2880.00  
Bulk inquire



Hydrogen bonding pattern: X  
Sugar: 2'-deoxyribose  
Heterocycle: Imidazotriazine  
Derivative: Free nucleoside  
Cat. No. XdIF-08010601  
100 mg \$ 550.00  
1 gram \$4400.00  
Bulk inquire

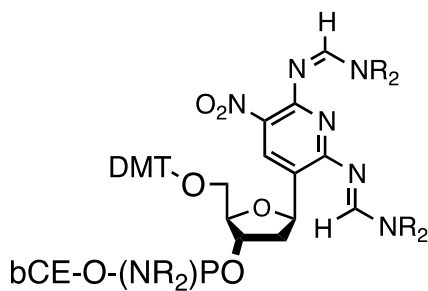


Hydrogen bonding pattern: X  
Sugar: 2'-deoxyribose  
Heterocycle: Purine  
Derivative: Free nucleoside  
Cat. No. XdRF-07010401  
100 mg \$ 230.00  
1 gram \$1840.00  
Bulk inquire

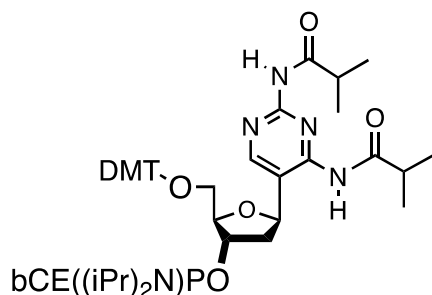
*Oligonucleotides are available with dK and/or dX in their multiple forms.  
Ribonucleosides are also available. Please inquire.*

# Artificially Expanded Genetic Information Systems

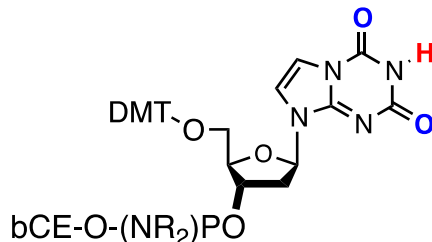
## The dK:dX system. Phosphoramidites



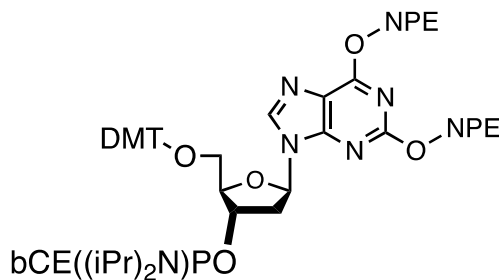
Hydrogen bonding pattern: K  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pyrimidine  
 Derivative: Phosphoramidite  
 Cat. No. KdNF-07010203  
 100 mg \$720.00  
 1 gram \$5760.00  
 Bulk inquire



Hydrogen bonding pattern: K  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Nitropyridine  
 Derivative: Phosphoramidite  
 Cat. No. KdNP-07010103  
 100 mg \$780.00  
 1 gram \$6240.00  
 Bulk inquire



Hydrogen bonding pattern: X  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Imidazotriazine  
 Derivative: Phosphoramidite  
 Cat. No. XdIP-08010603  
 100 mg \$480.00  
 1 gram \$3840.00  
 Bulk inquire

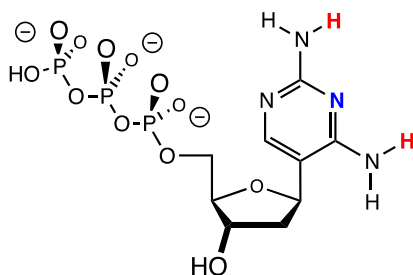


Hydrogen bonding pattern: X  
 Sugar: 2'-deoxyribose  
 Heterocycle: Purine  
 Derivative: Phosphoramidite  
 Cat. No. XdPP-08010403  
 100 mg \$252.00  
 1 gram \$2016.00  
 Bulk inquire

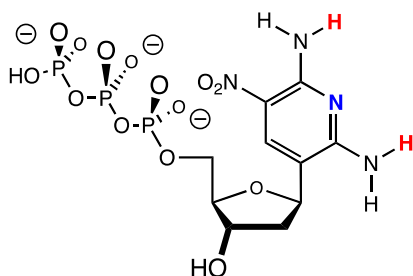
Ribonucleoside phosphoramidites are also available. *Please inquire.*

# Artificially Expanded Genetic Information Systems

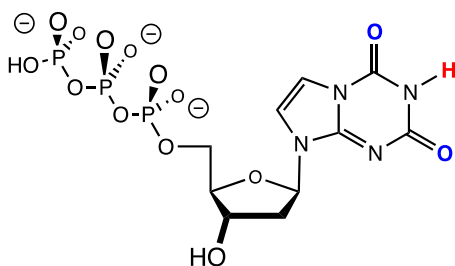
## The dK:dX system. Triphosphates and polymerases.



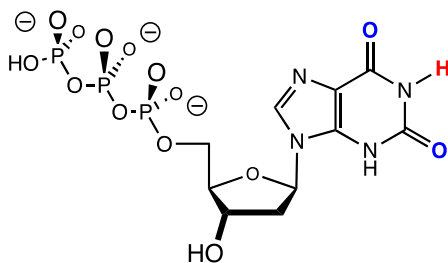
Hydrogen bonding pattern: K  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pyrimidine  
 Derivative: Triphosphate  
 Cat. No.: KdYT-07010104  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$1600.00  
 Bulk inquire



Hydrogen bonding pattern: K  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Nitropyridine  
 Derivative: Triphosphate  
 Cat. No.: KdNT-07010204  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$1600.00  
 Bulk inquire



Hydrogen bonding pattern: X  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Imidazotriazine  
 Derivative: Triphosphate  
 Cat. No.: XdIT-08010603  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$1600.00  
 Bulk inquire



Hydrogen bonding pattern: X  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Purine  
 Derivative: Triphosphate  
 Cat. No.: XdRT-08010404  
 1  $\mu$ mole \$300.00  
 5  $\mu$ moles \$1200.00  
 Bulk inquire

**Firebird** innovators have developed polymerases to incorporate dK opposite dX and dX opposite dK.

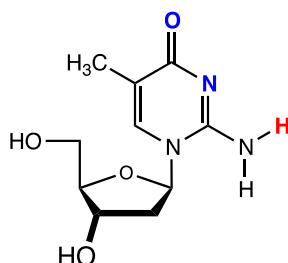
KiX Polymerase	400 units	\$300.00
KiXpOL475-ZY201	1000 units	500.00

Ribonucleoside triphosphates and supporting RNA polymerases are also available. *Please inquire.*

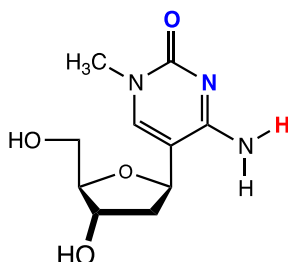
# Artificially Expanded Genetic Information Systems

## The dS:dB system. Nucleosides

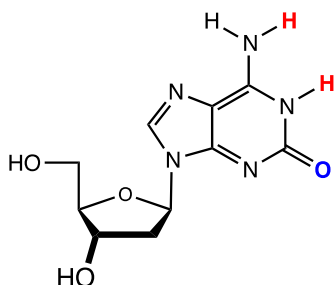
Multiple heterocycles implement the dS and dB hydrogen bonding patterns. All are available as nucleosides, phosphoramidites, & triphosphates.



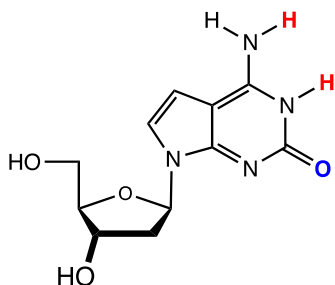
Hydrogen bonding pattern: S  
Sugar: 2'-Deoxyribose  
Heterocycle: Pyrimidine  
Derivative: Free nucleoside  
Cat. No.: SdYF-09010101  
100 mg \$50.00  
1 gram \$280.00  
Bulk inquire



Hydrogen bonding pattern: S  
Sugar: 2'-Deoxyribose  
Heterocycle: Pseudo  
Derivative: Free nucleoside  
Cat. No.: SdPF-09010801  
100 mg \$ 340.00  
1 gram \$2720.00  
Bulk inquire



Hydrogen bonding pattern: B  
Sugar: 2'-Deoxyribose  
Heterocycle: Purine  
Derivative: Free nucleoside  
Cat. No.: BdRF-10010401  
100 mg \$ 150.00  
1 gram \$ 900.00  
Bulk inquire

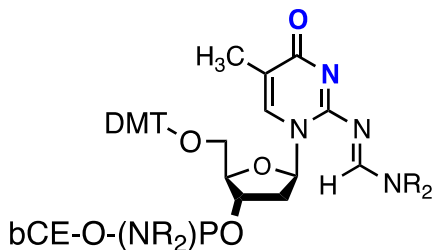


Hydrogen bonding pattern: B  
Sugar: 2'-Deoxyribose  
Heterocycle: Deazapurine  
Derivative: Free nucleoside  
Cat. No.: BdDF-10010501  
100 mg \$ 500.00  
1 gram \$ 4000.00  
Bulk inquire

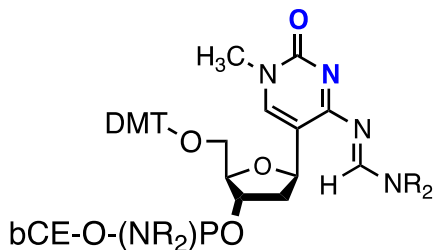
Oligonucleotides are available with dS and/or dB in their multiple forms. Ribonucleosides for the S:B system are also available. Please inquire.

# Artificially Expanded Genetic Information Systems

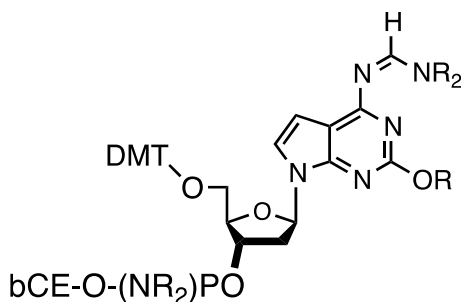
## The dS:dB system. Phosphoramidites



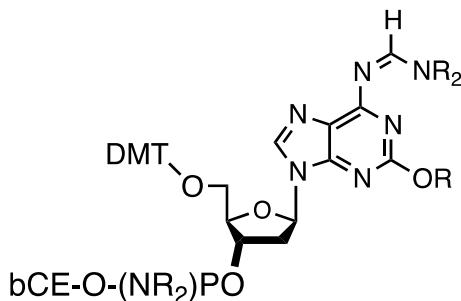
Hydrogen bonding pattern: S  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pyrimidine  
 Derivative: Phosphoramidite  
 Cat. No.: SdYP-09010103  
 100 mg \$ 180.00  
 1 gram \$ 900.00  
 Bulk inquire



Hydrogen bonding pattern: S  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pseudo  
 Derivative: Phosphoramidite  
 Cat. No.: SdPP-09010804  
 100 mg \$ 720.00  
 1 gram \$ 5760.00  
 Bulk inquire



Hydrogen bonding pattern: B  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Deazapurine  
 Derivative: Phosphoramidite  
 Cat. No.: BdRP-10010504  
 100 mg \$ 850.00  
 1 gram \$ 6800.00  
 Bulk inquire



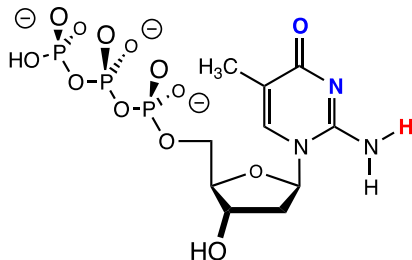
Hydrogen bonding pattern: B  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Purine  
 Derivative: Phosphoramidite  
 Cat. No.: BdDP-10010404  
 100 mg \$ 600.00  
 1 gram \$ 4800.00  
 Bulk inquire

Ribonucleoside phosphoramidites are also available. *Please inquire.*

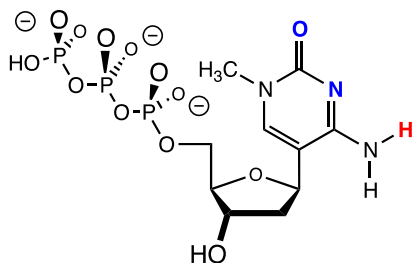


# Artificially Expanded Genetic Information Systems

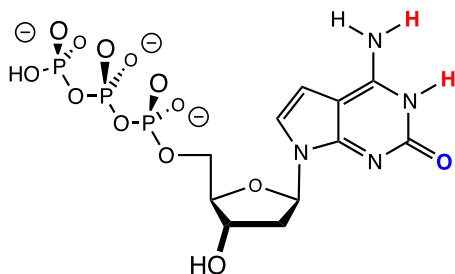
## The dS:dB system. Triphosphates and polymerases



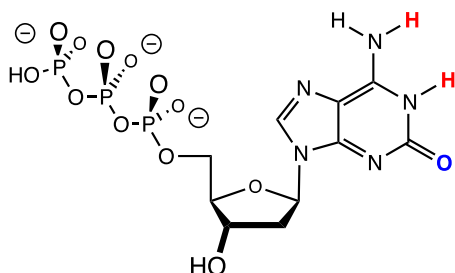
Hydrogen bonding pattern: S  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pyrimidine  
 Derivative: Triphosphate  
 Cat. No.: SdYT  
 1  $\mu$ mole \$150.00  
 5  $\mu$ moles \$900.00  
 Bulk inquire



Hydrogen bonding pattern: S  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Pseudo  
 Derivative: Triphosphate  
 Cat. No.: SdPT  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$3200.00  
 Bulk inquire



Hydrogen bonding pattern: B  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Deazapurine  
 Derivative: Triphosphate  
 Cat. No.: BdRT-10010504  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$3200.00  
 Bulk inquire



Hydrogen bonding pattern: B  
 Sugar: 2'-Deoxyribose  
 Heterocycle: Purine  
 Derivative: Triphosphate  
 Cat. No.: BdDT-10010404  
 1  $\mu$ mole \$400.00  
 5  $\mu$ moles \$3200.00  
 Bulk inquire

Firebird innovators have developed and tested polymerases to incorporate dS opposite dB and dB opposite dS.

SiB Polymerase 400 units \$300.00

SiBpOL475-ZY201 1000 units \$500.00

Ribonucleoside triphosphates are also available. *Please inquire.*



# Using AEGIS

## Ultra-clean nested PCR

Oligonucleotides up to 60 nts are available. Per 50 nmols, desalted (add \$150.00 for HPLC purification).

Setup \$90.00

Per nucleotide 0.85

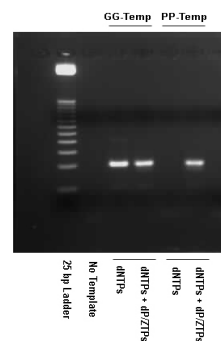
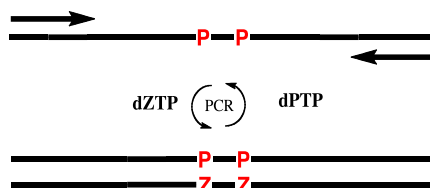
For each internal AEGIS 15.00

For each 3'--AEGIS 45.00

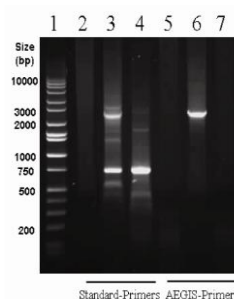
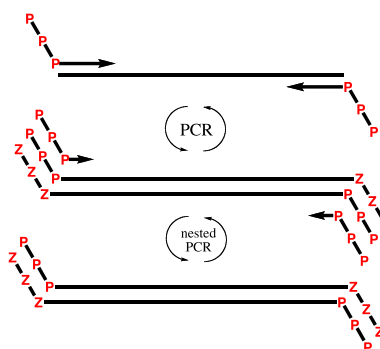
Shipping and handling \$40.00 per order plus \$6.00 per additional sequence.

## Using dZ and dP oligonucleotides

The dZ:dP pair is PCR amplified, even when adjacent in amplicons



dP in external primers cleans up nested PCR.



## AEGIS pairs improve molecular beacons

Sheng *et al.* (2008) Design of a novel molecular beacon. Modification of the stem with artificially genetic alphabet. *Chem. Comm.* (41) 5128

AEGIS beacons are available by custom synthesis. Please inquire.

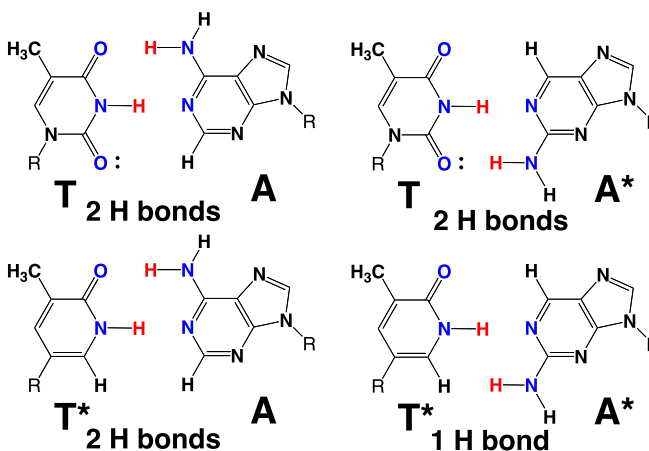
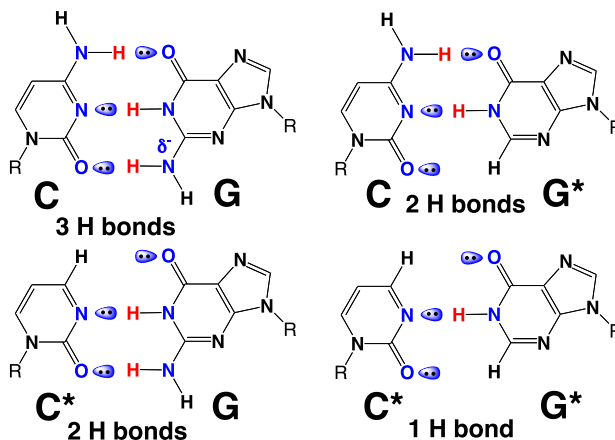
# Self avoiding molecular recognition systems

SAMRS™

## The concept

When multiplexing DNA priming or the polymerase chain reaction, various primers added in large amounts bind each other to create a PCR “mess”. Selectively removing hydrogen bonding units gives *self-avoiding* DNA primers that can be added without limit to enable multiplexed PCR.

The SAMRS™ concept idealized



**FIREBIRD**  
BIOMOLECULAR SCIENCES, LLC

# Self avoiding molecular recognition systems

## SAMRS™ phosphoramidites

T\* phosphoramidite

1 g \$ 1050

10 g \$ 8220

A\* phosphoramidite

1 g \$ 655

10 g \$ 5340

C\* phosphoramidite

1 g \$ 394

10 g \$3150

G\* phosphoramidite

1 g \$ 110

10 g \$ 880

Recommended lengths are 20-35 nts with 4-6 SAMRS components.

A set of 48 SAMRS oligonucleotides with customer-selected selected is available for \$4800.

Contact for pricing for smaller numbers of SAMRS oligonucleotides.

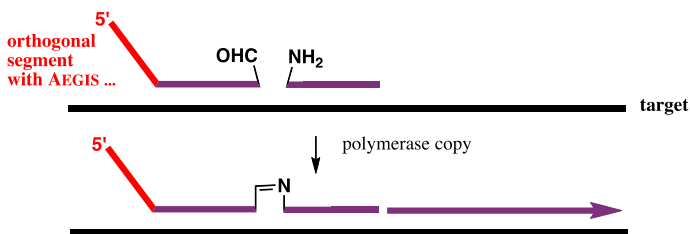
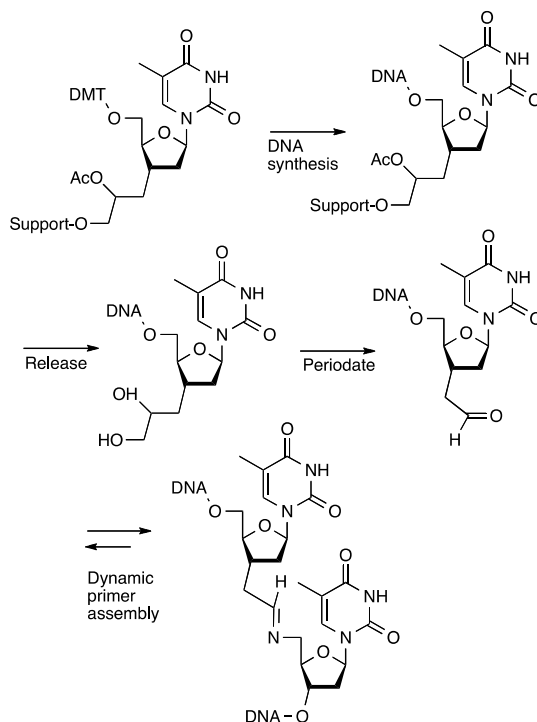


# SNAP2™ Oligonucleotides

Priming with both high specificity *and* high discrimination

## The concept

When priming, one needs the specificity of a 16mer (or longer) but the ability to discriminate against single mismatches. Dynamic assembly of a primer on a template can provide this.



Controlled pore glass with aldehyde precursor  
SNAP2T\_HJK001      100 mg      \$600.00

Leal, N., Sukeda, M., Benner, S. A. (2006) Dynamic assembly of primers on nucleic acid templates. *Nucleic Acids Res.* **34**, 4702-4710

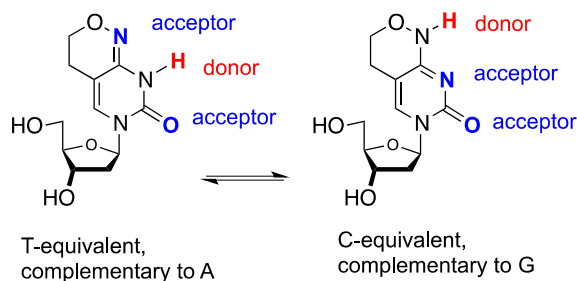
Not to be confused with Snap-Tag® and other registered trademarks of New England BioLabs.

# Biversal™ nucleotides

Often, target xNA sequences divergently evolve, making it impossible to know the exact complement to use as a probe or primer. This is often handled using “universal bases” (e.g. inosine). Inspired by the work of Dan Brown, **Firebird** scientists have rolled evolutionary analyses into nucleoside chemistry to create two “biversals”™, a purine biversal that pairs with either thymine or cytosine and a pyrimidine biversal that pairs with either guanine or adenine.

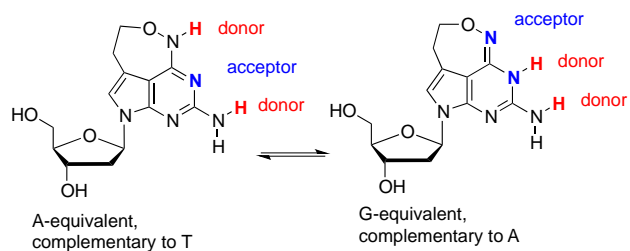
## Pyrimidine biversal phosphoramidite

100 mg \$ 500  
1 g \$ 4000



## Purine biversal phosphoramidite

100 mg \$ 1050  
1 g \$ 8220



For oligonucleotides that contain the purine and pyrimidine biversals, *please inquire*.

# Purchasing, shipping and handling

## Contact

### Orders

By email: [orders@firebirdbio.com](mailto:orders@firebirdbio.com)

By telephone: Firebird Biomolecular Sciences  
(386) 418-0347

9:00 - 5:00 east coast time

### Technical inquiries

[support@firebirdbio.com](mailto:support@firebirdbio.com)

Reagents and enzymes are shipped at the customer's expense, on dry ice as appropriate.

