

Product Profile

Custom Oligo Synthesis, antisense oligos, RNA oligos, chimeric oligos,
Fluorescent dye labeled oligos, Molecular Beacons, TaqMan Probes
Locked Nucleic Acids (LNA), siRNA, Aptamers

Fluorescent Molecular Probes

For research use only. Not for use in diagnostic procedures for clinical purposes.

Oligo Types & Modifications

Molecular Beacons
TaqMan® Probes
Aptamers
RNA Probes
Fluorophores & Quenchers
Propyne dC and dU labeled Oligos
Phosphorothioate Oligos
2'-5' linked Oligos
Methylated Oligos

Applications

Real Time Quantitative PCR Analysis (QPCR) Probes
Fluorescent Genotyping
siRNA Gene Knockout Validation
Allelic Discrimination
Antisense Targeting
SNP Detection
Aptamers Detection Probes



Fluorescent Molecular Probes

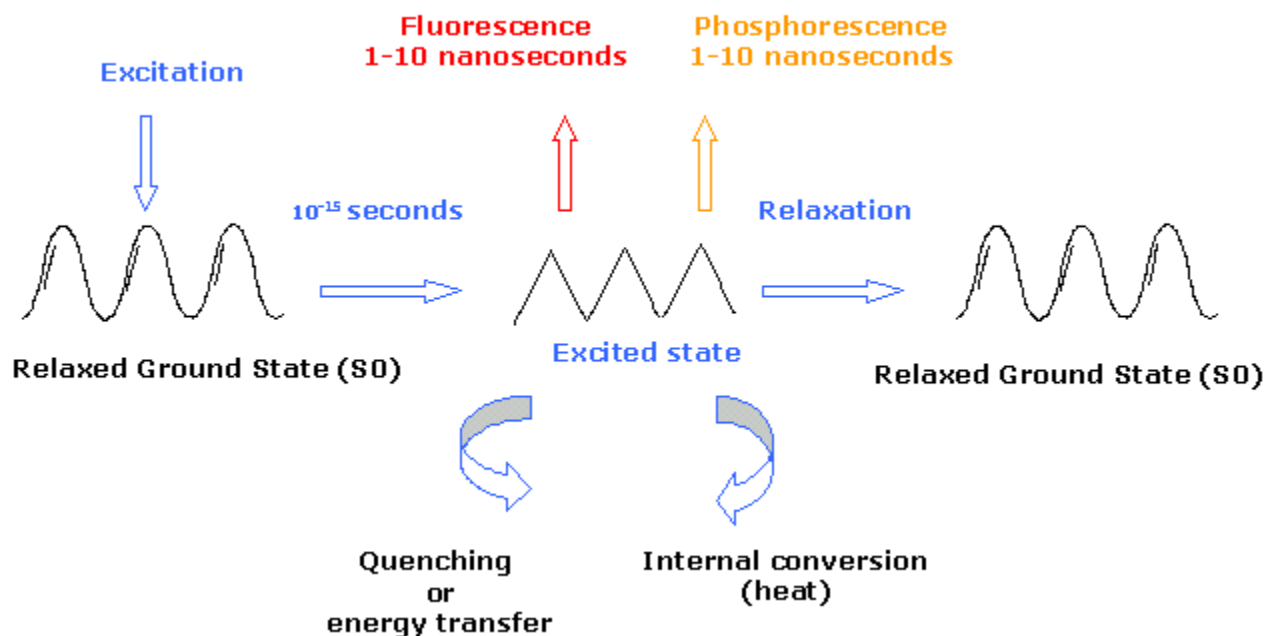
The use of fluorescent dyes in molecular biology has rapidly transformed from just single dye-labeled primers for fragment analysis to the use of dual-labeled oligos, containing dyes and dark quenchers, as probes for quantitative analysis. Fluorescence based detection offers a safe and sensitive method for quantitative detection. This also means that molecular biologists have to understand new terms like donors, acceptors, quenchers, FRET, Stokes shift etc. The molecular basis of some of the probe designs are simple and elegant, and thus have led to an exponential use of molecular probes, and consequently, furthering new developments. Because all of these methods are fluorescence-based, it is essential to understand the basic concepts of fluorescence.

Gene Link offers synthesis of all different forms of molecular probes. We provide technical service in the design of novel probes and have synthesized numerous combinations of dyes, quenchers, RNA, phosphorothioate, 2'O methyl and chimeric probes.

Luminescence, Phosphorescence & Fluorescence Defined

Molecules absorb energy as photons of light are shined on them. The property of photon absorption depends on the particular atomic configurations of the molecules in question, with said absorption leading to an excited energy state. The energy that is absorbed can be translated into rotational, vibrational or electronic modes. The exact fate of the energy depends on the wavelength of the incoming light; the longer the wavelength, the lower the energy. The vibrational and rotational energy levels are closer together than the electronic levels. Thus, changes in the electron configuration within these levels are often associated with the absorption of infrared radiation and subsequent release of energy as heat. However, light in the visible and UV regions of the spectrum have enough energy to cause changes in the electronic states of a molecule without a relative elevation of temperature.

- **Luminescence** The release of energy as light at low temperature is termed luminescence. The molecules emitting light are relatively cool. It is in contrast to light bulbs, fire etc. Luminescence is a general term not limited to the duration of the emitted light.
- **Phosphorescence** Delayed luminescence after absorption of energy. The wavelength of the released light energy is at a different (and lower) wavelength and it continues for an extended period of time, even after excitation has ceased.
- **Fluorescence** Instantaneous luminescence after absorption of energy. The fluorescence is usually at a different (and lower) wavelength and it ceases almost at once when excitation has ceased.



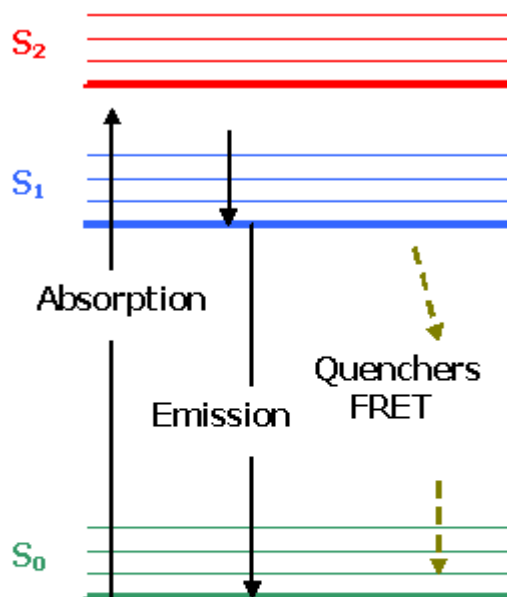
Excitation and Emission

The excitation level of molecules varies at different wavelengths. Molecules exposed to a beam of light usually absorb much more energy at one particular wavelength than others. This specific wavelength is termed the Excitation Maximum. By contrast, the Emission Maximum is the wavelength at which the maximum amount of light is released after a previous light absorption event. The molecule stays in the excited state for a finite time, usually <1-10 nanoseconds in the case of fluorescence, and returns to the relaxed state with emission of energy. The lifetime is measured in nanoseconds, for example, the lifetime of Cy3 is <0.3ns and Cy5 is 1.0ns. Excitation and Emission is a cyclic process and consequently can be repeated for a molecule unless damaged by the energy absorption, at which point the process ceases for that molecule, an effect termed as photobleaching.

We will now focus our discussion by referring to fluorescent dyes used for molecular probes and primer design. The popular ones in use are Fluorescein, 6-FAM (6-fluorescein amidite), HEX (hexachloro fluorescein), TET (tetrachloro fluorescein), all other fluorescein derivatives, Cy series dyes, the Alexa series dyes and rhodamine derivatives. The dyes are selected based on their excitation and emission wavelengths, rate of photobleaching, quenching efficiency and various other biophysical factors. All dyes when excited undergo a conformational change based on their interaction with other molecules, bases and dyes in close proximity. The emission is thus bound by these variables of the microenvironment interaction. Thus, the amount of energy emitted will vary, and not all the energy absorbed during excitation is released as fluorescence.

The excitation time usually is in picoseconds to nanoseconds; similarly the emission time is in a nanoseconds time frame. The energy used for excitation elevates the dye from a stable and relaxed ground state (S₀) to an excited state (S₁, S₂, etc). If the excitation is to S₂ (a vibrational state), the transition from S₂ to S₁ (an electronic state) is without any release of light energy, just heat energy. The light energy of the photons subsequently emitted from the excited S₁ state on the electrons' return to the relaxed, ground S₀ state is thus less than that of the photons initially absorbed to excite the electrons to S₂. As a result, the Excitation and Emission Maxima will occur at

different wavelengths, with the latter always being lower than the former. The difference in wavelength between the Excitation and Emission Maxima is termed the Stokes shift. The Stokes shift represents the energy lost as heat while the molecule was in the excited state.



Absorption of a photon and excitation to S₁ or S₂. Radiationless energy loss and return to S₁. Return to S₀ from S₁ with emission of fluorescence or by energy transfer to quenchers or other acceptor dye (FRET).

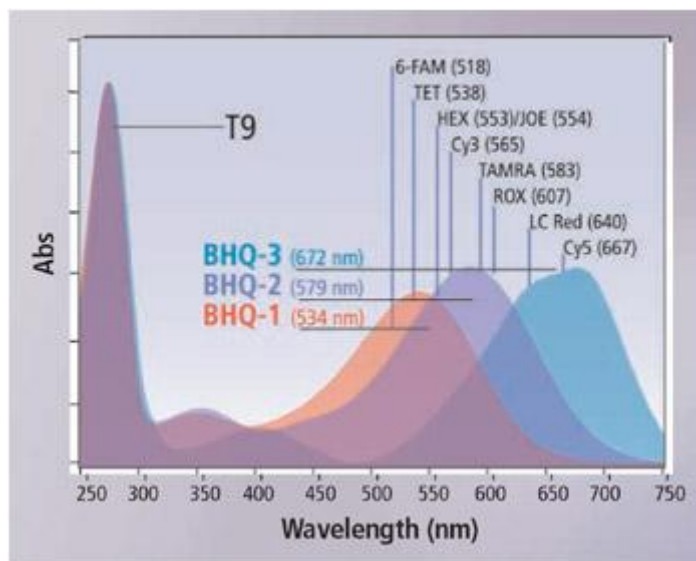
Quenching

Reduction in the expected fluorescence emission intensity is termed quenching. Generally, it would be an impediment if the emission intensity were reduced. The phenomenon of quenching forms the basis of the mode of action of certain molecular probes; the designed and controlled fluorescence based on hybridization to the target sequence.

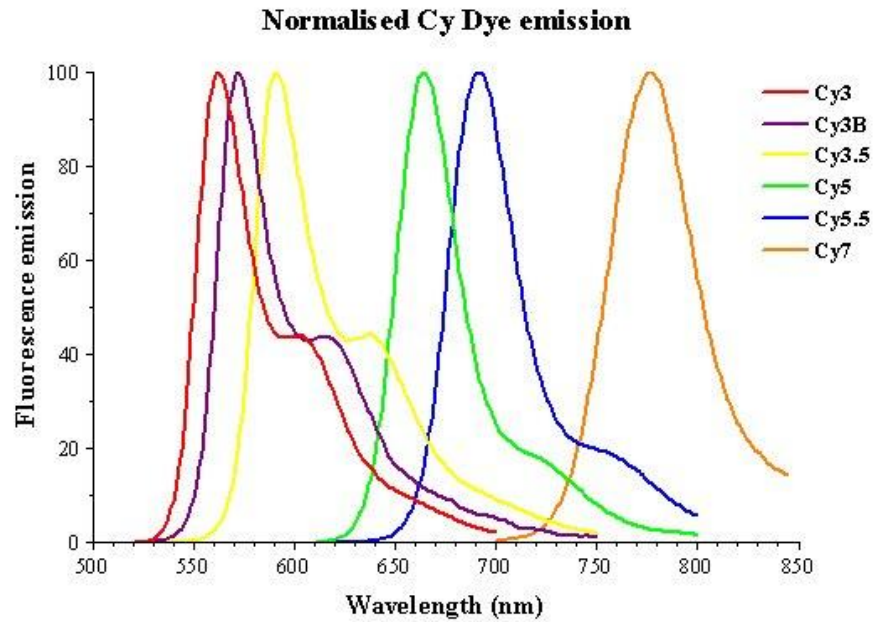
Natural quenching occurs due to 'fading' after repeated cycles of excitation and relaxation. The decrease in the ability of further excitation of a proportion of molecules is termed as photobleaching. Photobleaching is due to structural damage of molecules due to absorption of high energy photons. Some dyes are much more sensitive than others to photobleaching, for example, fluorescein photobleaches very easily. Often the rate of decomposition is proportional to the intensity of illumination. So a simple practical way to overcome this is to reduce the incident radiation. It is sometimes possible to introduce antioxidants, such as phenylalanine or azide, to reduce bleaching. Quenching is also observed when the concentration of the dye is too high and the overall brightness decreases. This is 'self quenching'. It is observed that multiple labeling of an oligo with the same dye does not always lead to an increase in fluorescence.

Placing a molecule that absorbs light in close proximity to the fluorophore can induce quenching. Quenching is distance-dependent, quite similar to Fluorescence Resonance Energy Transfer (FRET), and it can be assumed that the energy transfer typically occurs over a distance of 1-10 nm. The distance of 10 nm is equivalent to approximately 30 nucleotides with each nucleotide being 3.4 Å

(0.34 nm). The placement of dyes to achieve FRET thus will thus be dependent on the distance they are apart from each other with either nucleotides or spacers. The quenching effect is exhibited by fluorescent as well non-fluorescent molecules. A non-fluorescent ("dark") quencher is the basis of the design of Molecular Beacons. This molecule could be non-fluorescent and acts as an energy sink, and is termed a quencher. In other instances, this molecule could itself be a dye with overlapping absorption and emission spectra; in such cases, energy is transferred from one to the other without any emission of light energy. This is termed as resonance energy transfer. Generally, the term 'quencher' is used for non-fluorescent molecules in probe design, and 'double dye' or 'dual dye' used for probes with two dyes having spectral overlap.



| Quencher Spectral Data | | |
|------------------------|---------------------|----------------------|
| Quencher | Absorbance max (nm) | Quenching Range (nm) |
| Dabcyl | 453 | 425-520 nm |
| BHQ-1 | 534 | 480-580 nm |
| BHQ-2 | 579 | 559-650 nm |
| BHQ-3 | 672 | 620-730 nm |



| Fluorophore Spectral Data and Quencher Selection Guide | | | | |
|--|---------|---------------------|-------------------|----------------|
| Fluorophore | Color | Absorbance max (nm) | Emission max (nm) | Quencher Guide |
| 6-FAM (Fluorescein) | Green | 494 | 525 | BHQ-1/Dabcyl |
| TET | Orange | 521 | 536 | BHQ-1/Dabcyl |
| HEX | Pink | 535 | 556 | BHQ-1/Dabcyl |
| Cy 3 | Red | 552 | 570 | BHQ-2 |
| Cy 3.5 | Purple | 588 | 604 | BHQ-2 |
| Cy 5 | Violet | 646 | 667 | BHQ-3 |
| Cy 5.5 | Blue | 683 | 707 | BHQ-3 |
| Cy 7 | Near IR | 743 | 767 | BHQ-3 |
| Tamra | Rose | 565 | 580 | BHQ-2 |
| ROX | Purple | 587 | 607 | BHQ-2 |
| JOE | Mustard | 528 | 554 | BHQ-1/Dabcyl |
| Texas Red-X | Red | 583 | 603 | BHQ-2 |
| Cascade Blue | Blue | 396 | 410 | BHQ-1/Dabcyl |
| Marina Blue | Blue | 362 | 459 | BHQ-1/Dabcyl |
| Alexa Fluor® Dye | Varies | Varies | Varies | Varies |
| Please see our complete list at www.genelink.com or call at 1-800-436-3546 | | | | |

Fluorescence Resonance Energy Transfer (FRET)

Resonance energy transfer, often known as fluorescence resonance energy transfer (FRET) or Förster energy transfer. It is the radiation-less transfer of excitation energy from a donor to an acceptor. An important consequence of this transfer is that there is no emission of light by the donor. The acceptor may or may not be fluorescent. FRET is a distance-dependent interaction where the energy transfer occurs typically over a distance of 1-10 nm. The distance dependent nature of FRET is highlighted by the fact that it is proportional to the inverse sixth power of the intermolecular separation. The fact that FRET typically occurs in the 1-10 nm region means that these separation distances are comparable with the dimensions of biological macromolecules. This means that FRET can be a valuable tool in studying proximity events in biological systems. One helical turn is ~ 3.4 nm and comprises 10 nucleotides. A nucleotide is thus ~ 0.34 nm or 3.4 \AA ($1 \text{ \AA} = 0.1 \text{ nm}$). Thus, to observe FRET and quenching the donor and acceptor should not be placed more than 30 nucleotides away.

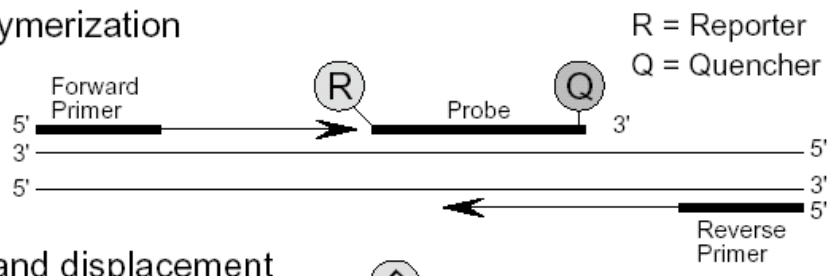
FRET varies based on the degree of spectral overlap of the donor and acceptor. That is to say, the degree to which the emission band of the donor and the absorption band of the acceptor overlap. This is called the "spectral overlap" or sometimes the "Förster overlap integral". This describes the amount of overlap where resonance can occur, i.e. where the donor and acceptor have the same frequencies.

There are many other applications and consequences arising from these equations. For example if the donor and acceptor are the same molecular species it is still possible to observe FRET. This is called homo-transfer and could be thought of as energy migration. The obvious conclusion from this is that the observed fluorescence would not be changed. However, at high concentration of dye it is possible to observe concentration quenching. In this case the transfer of the energy does not result in emission, and the explanation for this is that the transfer is occurring at less than a critical distance and some of the dyes are acting as energy sinks (Source: Amersham Biosciences Website).

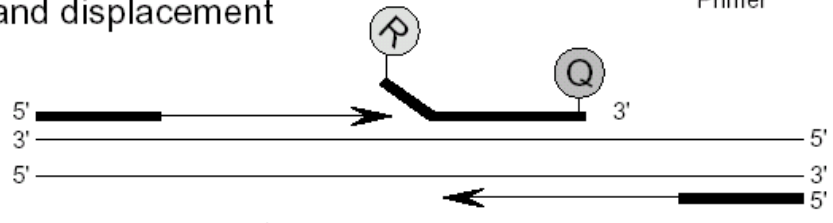
TaqMan

TaqMan (also known as Fluorogenic 5' nuclease assay) probes contain two dyes, a reporter dye (e.g. 6-FAM) at the 5' end and a 3' acceptor dye, usually TAMRA. Recent designs substitute the 3' TAMRA fluorescent acceptor quencher dye with non-fluorescent quencher, e.g. Black Hole Quencher. The proximity of the quencher to the reporter in an intact probe allows the quencher to suppress, or "quench" the fluorescence signal of the reporter dye through FRET. If the target of interest is present, these probes specifically anneal between the forward and reverse primer sites. During the reaction, the 5' to 3' nucleolytic activity of Taq polymerase cleaves the probe between the reporter and the quencher only if the probe hybridizes to the target. The probe fragments are displaced from the target, separating the reporter dye from the quencher dye and thus resulting in increased fluorescence of the reporter. Accumulation of PCR products is detected directly by monitoring the increase in fluorescence of the reporter dye. Because increase in fluorescence signal is detected only if the target sequence is complementary to the probe, nonspecific amplification is not detected.

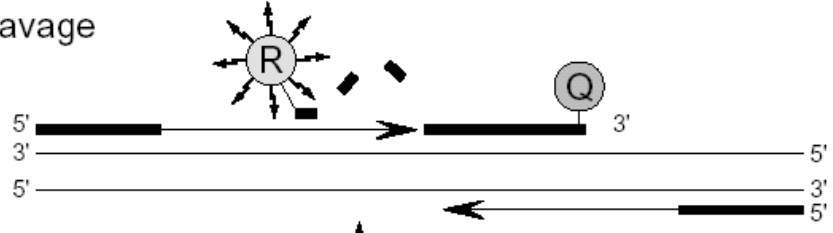
Polymerization



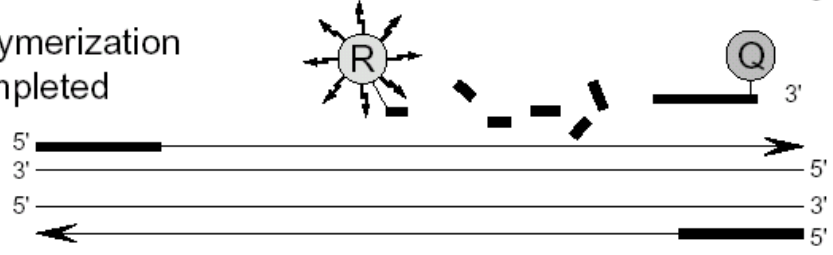
Strand displacement



Cleavage



Polymerization completed



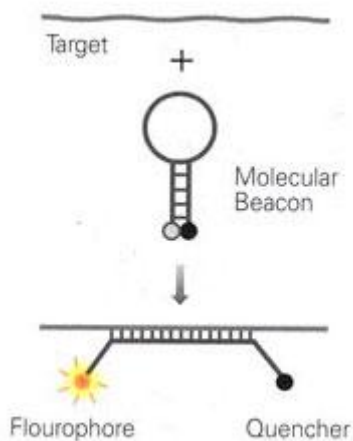
Design of TaqMan Primers and Probes

Some guidelines for TaqMan probes and primers selection are as follows:

- G-C content between 20% and 80%
- Avoid runs of an identical nucleotide, especially guanine
- Avoid G to be on the 5' end
- Probes and primers should contain more C than G
- Melting temperature (T_m) should be 68-70°C for probes and 58-60°C for primers
- The five nucleotides at the 3' end of each primer should have no more than two Gs and/or Cs
- Give precedence to better probes over primers
- Probe should be as close to 5' primer as possible without overlapping

Molecular Beacons

Molecular beacons are oligonucleotide probes that can report the presence of specific nucleic acids in homogenous solutions (Tyagi S, Kramer FR. Molecular beacons: probes that fluoresce upon hybridization, Nature Biotechnology 1996; 14: 303-308.) They are useful in situations where it is either not possible or desirable to isolate the probe-target hybrids from an excess of the hybridization probes, such as in real time monitoring of polymerase chain reactions in sealed tubes or in detection of RNAs within living cells. Molecular beacons are hairpin shaped molecules with an internally quenched fluorophore whose fluorescence is restored when they bind to a target nucleic acid (Figure 1). They are designed in such a way that the loop portion of the molecule is a probe sequence complementary to a target nucleic acid molecule. The stem is formed by the annealing of complementary arm sequences on the ends of the probe sequence. A fluorescent moiety is attached to the end of one arm and a quenching moiety is attached to the end of the other arm. The stem keeps these two moieties in close proximity to each other, causing the fluorescence of the fluorophore to be quenched by energy transfer. Since the quencher moiety is a non-fluorescent chromophore and emits the energy that it receives from the fluorophore as heat, the probe is unable to fluoresce. When the probe encounters a target molecule, it forms a hybrid that is longer and more stable than the stem and its rigidity and length preclude the simultaneous existence of the stem hybrid. Thus, the molecular beacon undergoes a spontaneous conformational reorganization that forces the stem apart, and causes the fluorophore and the quencher to move away from each other, leading to the restoration of fluorescence.



Operation of molecular beacons: On their own, these molecules are non-fluorescent, because the stem hybrid keeps the fluorophore close to the quencher. When the probe sequence in the loop

hybridizes to its target, forming a rigid double helix, a conformational reorganization occurs that separates the quencher from the fluorophore, restoring fluorescence.

In order to detect multiple targets in the same solution, molecular beacons can be made in many different colors utilizing a broad range of fluorophores (Tyagi S, Bratu DP, Kramer FR. Multicolor molecular beacons for allele discrimination, Nature Biotechnology 1998; 16: 49-53.) DABCYL, a non-fluorescent chromophore, serves as the universal quencher for any fluorophore in molecular beacons. Owing to their stem, the recognition of targets by molecular beacons is so specific that single-nucleotide differences can be readily detected.

Molecular Beacon Example Sequence

Fluorophore at 5' end; 5'-GCGAGCTAGGAAACACCAAAGATGATATTTGCTCGC -3'-Quencher

```
5' GCGAGCTAGGAAACACCA
   ||||| ]
3' CGCTCGTTTATAGTAGAA
STEM AT 1 IS 6 BP LONG. LOOP = 24.
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The vertical lines at the 5' and 3' ends identify the arm sequences that are complementary.

The length of the probe sequence (10-40 nt) is chosen in such a way that the probe target hybrid is stable in the conditions of the assay. The stem sequence (5-7 nt) is chosen to ensure that the two arms hybridize to each other but not to the probe sequence. Folding of the designed sequence with the help of a computer program can indicate whether the intended stem-and-loop conformation will occur. The computer program can also predict the melting temperature of the stem.

Signal to background ratio

1. Determine the fluorescence (F_{buffer}) of 200 μl of molecular beacon buffer solution using 491 nm as the excitation wavelength and 515 nm as the emission wavelength. If the fluorophore is not fluorescein, choose wavelengths that are optimal for the fluorophore in the molecular beacon.
2. Add 10 μl of 1 μM molecular beacon to this solution. Record the new level of fluorescence (F_{close})
3. Add a two-fold molar excess of the oligonucleotide target and monitor the rise in fluorescence until it reaches a stable level (F_{open}).
4. Calculate the signal to background ratio as $(F_{\text{open}} - F_{\text{buffer}}) / (F_{\text{close}} - F_{\text{buffer}})$.

Thermal denaturation profiles

1. Prepare two tubes containing 50 μl of 200 nM molecular beacon dissolved in 3.5 mM MgCl_2 and 10 mM Tris-HCl, pH 8.0 and add the oligo target to one of the tubes at a final concentration of 400 nM.
2. Determine the fluorescence of each solution as a function of temperature using a thermal cycler with the capacity to monitor fluorescence. Decrease the temperature of these tubes from 80 $^{\circ}\text{C}$ to 10 $^{\circ}\text{C}$ in 1 $^{\circ}\text{C}$ steps, with each hold lasting one min, while monitoring the fluorescence during each hold.

Real time monitoring of polymerase chain reactions

Utilize molecular beacons that are complementary to a sequence in the middle of the expected amplified target fragment. The length of their arm sequences should be chosen so that a stem is formed at the annealing temperature of the polymerase chain reaction. The length of the loop sequence should be chosen so that the probe-target hybrid is stable at the annealing temperature. Whether a molecular beacon actually exhibits these designed features is determined by obtaining thermal denaturation profiles. The molecular beacons with appropriate thermal denaturation characteristics are included in each reaction at a concentration similar to the concentration of the primers. During the denaturation step, the molecular beacons assume a random coil configuration and fluoresce. As the temperature is lowered to allow annealing of the primers, stem hybrids form rapidly, preventing fluorescence. However, at the annealing temperature, molecular beacons also bind to the amplified target fragment and generate fluorescence. When the temperature is raised to allow primer extension, the molecular beacons dissociate from their targets and do not interfere with polymerization. A new hybridization takes place in the annealing step of every cycle, and the intensity of the resulting fluorescence indicates the amount of accumulated amplified target fragment.

Procedure

1. Set up six 50 μl reactions so that each contains a different number of targets, 0.34 μM molecular beacon, 1 μM of each primer, 2.5 units of Taq polymerase, 0.25 mM of each deoxyribonucleotide, 3.5 mM MgCl_2 , 50 mM KCl, and 10 mM Tris-HCl, pH 8.0.
2. Program the thermal cycler to incubate the tubes at 95 $^{\circ}\text{C}$ for 10 min to activate Amplitaq Gold DNA polymerase (omit this step if not using hot start DNA polymerase), followed by 40 cycles of 30 sec at 95 $^{\circ}\text{C}$, 60 sec at 50 $^{\circ}\text{C}$ and 30 sec at 72 $^{\circ}\text{C}$. Monitor fluorescence during the 50 $^{\circ}\text{C}$ annealing steps.

Troubleshooting

- The assay medium may contain insufficient salt. There should be at least 1 mM MgCl₂ in the solution, in order to ensure that the stem hybrid forms.
- The molecular beacon may fold into alternate conformations that result in a sub-population that is not quenched well. Change the stem sequence (and probe sequence, if necessary) to eliminate that possibility.
- Incomplete restoration of fluorescence at low temperatures. If the stem of a molecular beacon is too strong, at low temperatures it may remain closed while the probe is bound to the target. This may happen inadvertently if the probe sequence can participate in the formation of a hairpin that results in a stem longer and stronger than originally designed. Change the sequence at the edges of the probe and the stem sequence to avoid this problem.

Molecular Beacon Design

The PCR primers themselves should have been optimized in a regular PCR to see that it performs well. Assuming the melting temperature of the primers are ~55 degrees.

There are two independent features to control in the design of the MB probe. The stem and the target loop sequence. Design the probe sequence and see that there is minimal secondary structures, loop formation and dimers and the TM is ~5 degree higher than the PCR primer annealing temp. For a good guideline keep it at ~60 degrees. Add the stem sequence of 5-7 bp. The TM of the stem itself will be ~ 60-70 degrees. You are done!.

General guidelines for MB design at Gene Link are as follows:

1. Design regular 18-24mer PCR primers for amplification with a TM around 55°C. The optimal amplified fragment should be between 100-300 bp. Perform PCR, optimize conditions. Should get good clean amplification product visible on ethidium bromide stained gels.
2. Design target probe sequence with a TM ~8-10 degrees higher than the PCR primers annealing temp. Example 60-65 degrees. The probe should be designed near the center of the amplified fragment avoiding stretches of strong secondary structure. [Taqman probes are designed ~ 5-10 bases near the primer of the same strand]
3. Add the stem 5- 7 bp stem sequence with a GC content of 70-80%. Avoid a G at the 5' end next to the fluorophore. G's seem to have a quenching effect. Hairpin Stem TM should be 7-10 degrees higher than the PCR annealing temperature. Example 65-70 degrees.

Caution: See that by adding the stem you have not created secondary structures with the loop sequence. Try variation of stem sequence to avoid secondary structure with the loop sequence.

The Hairpin stem TM is based on free energy stabilization and folding, the following is a good guideline.

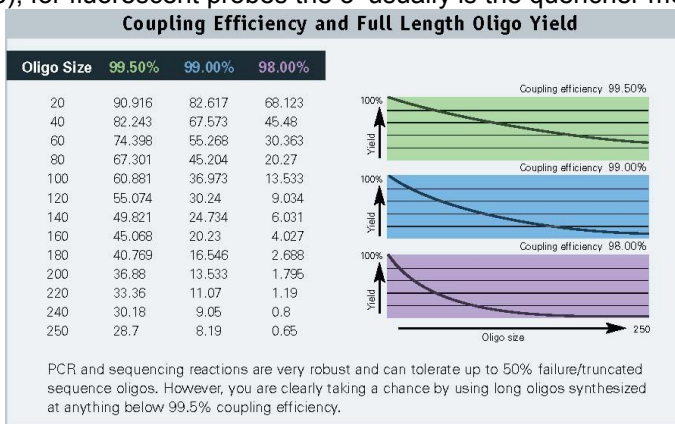
GC rich stem
5 bp = 55°C- 60°C
6 bp = 60°C-65°C
7 bp = 65°C-70°C

Yield

Chemical synthesis of oligo starts from the 3' direction and proceeds to the 5'. All automated synthesis use a solid support that is attached with the first base (nucleoside), for fluorescent probes the 3' usually is the quencher moiety that is attached to the solid

support. The scale of synthesis determines the nanomole (nmol) of first base/quencher or fluorophore. The overall crude nmol yield of full-length oligo depends on the average coupling efficiency of each base and on the number of couplings, as the oligo length increases the overall yield of full length product decreases.

At Gene Link we maintain a coupling efficiency of 98-99%. Yields of full-length fluorescent probes vary considerably based on the type of fluorophore and quencher. Most fluorescent dyes that are used directly for coupling on automated DNA synthesizers have a coupling efficiency above 85%, whereas the dyes that are conjugated based on NHS chemistry (succinimidyl ester) is a post synthesis conjugation to amino labeled probes. Gene Link minimum yield guarantees are based on the synthesis, type of dye and purification of your oligo.



Gene Link offers synthesis of all different forms of molecular primers and probes. We provide technical service in the design of novel probes and synthesize numerous combinations of dyes, quenchers, RNA, phosphorothioate, 2'O methyl, ultramodified and chimeric probes.

The table below lists the yields for common dyes for use in TaqMan probes with Tamra or BHQ at 3' end and Molecular Beacons with universal fluorescence quencher dabcyf or BHQ at 3' end. Gene Link considers gel purification to be the best method of purification and essential for optimum performance of fluorescent dye labeled oligonucleotides.

| Fluorescent Probes Guaranteed Yield* | | | | | | |
|--|---------------------|------------|----------------------|------------|--------------------|------------|
| Dye/Quencher | 50 nmol scale Yield | | 200 nmol scale Yield | | 1 µmol scale Yield | |
| | Crude | Purified** | Crude | Purified** | Crude | Purified** |
| 5' 6-Fam, Hex or Tet/3' Tamra, BHQ1 or Dabcyl | 20 nmol | 10 nmol | 50 nmol | 20 nmol | 200 nmole | 40 nmole |
| 5'-Cy3 or Cy5/BHQ2 | 10 nmol | 5 nmol | 40 nmol | 10 nmol | 100 nmole | 20 nmole |
| 5' -Cy3.5, Cy5.5, Rox, Texas Red, Alexa Fluor Dyes, NHS Dyes etc./quencher | 2 nmol | 1 nmol | 16 nmol | 8 nmol | 30 nmole | 16 nmole |

*Guaranteed yield for dye and quencher listed. Lower yield with additional modifications. ** Purified yield is for RPC (reverse phase purification) or gel purified (PAGE, polyacrylamide gel electrophoresis). Inquire for higher scale of synthesis

Reconstitution, Use & Stability of Fluorescent Probes

All Gene Link custom oligo products including, molecular probes, RNA and siRNA includes a datasheet that contains the exact nmols, μg , A_{260} units(OD Units) and other physical data. This data is important for reconstituting the product. All fluorescent probes are shipped in amber tubes to prevent exposure to light and minimize photobleaching. Gene Link guarantees the stability of oligos for 1 year and fluorescent molecular probes for 6 months if reconstituted and stored appropriately as detailed below.

In our experience unmodified oligos are stable for numerous years if reconstituted and stored properly. Avoid multiple freeze thaws; do not exceed 6-10 freeze thaw cycles. If the same oligo is intended to be used repeatedly then it is prudent to make a numerous aliquots of the stock solution and frozen.

Reconstitution & Storage

Gene Link oligos are supplied lyophilized. These are stable at room temperature for an extended period of time. The oligonucleotide should preferably be frozen upon receipt. TE buffer (10mM Tris, 1mM EDTA, pH 7.5) is recommended for dissolving the oligonucleotides; EDTA inhibits the activity of the nucleases.

| Preferred TE Buffer Reconstitution & Storage pH for Fluorescent Probes | |
|--|-------------------------|
| 6-FAM, HEX, TET, ROX, and TAMRA | TE Buffer pH 7.5 or 8.0 |
| Cy3, Cy3.5, Cy5, and Cy5.5 | TE Buffer pH 7.0 or 7.5 |
| Cy dyes rapidly degrade in acidic pH | |

Further dilution can be made in TE buffer. After reconstitution store the stock solution at -80°C or -20°C . Fluorescently labeled oligos should be stored in light-free conditions.

Preparation of Stock Solution of 100 pmols/ μl [100 μM]

Gene Link provides the exact amount of nmols of each oligo supplied on the tube and on the Oligo Report. Multiply the 'nmol' amount by 10 to arrive at the volume of TE to be added.

Example: $45.10\text{nmols} \times 10 = 451\mu\text{l}$

Dissolve the oligo in $451\mu\text{l}$ to get 100pmols/ μl stock solution.

Use as required.

Dilute 10 fold to prepare a 10pmols/ μl [10 μM]. Use as required.

For optimal long-term storage, it is recommended that the oligonucleotides should be stored dry at -20°C in the dark. If numerous experiments are planned using the same oligonucleotide, prepare aliquots, dry them and store the aliquots at -20°C .

Stability

Gene Link guarantees the stability of oligos for 1 year and fluorescent molecular probes for 6 months if reconstituted and stored appropriately as recommended by Gene Link. The stability can be increased several fold by instituting proper handling conditions, avoiding exposure to light and multiple freeze thaws.

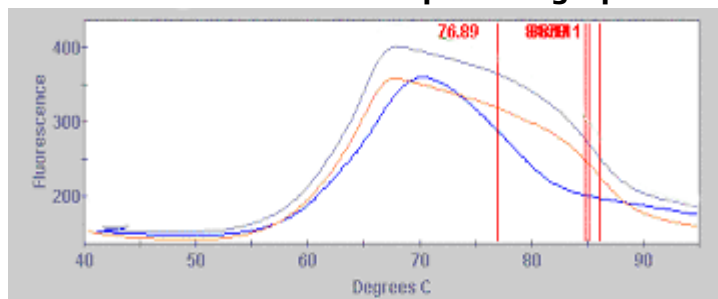
Gene Link Molecular Beacon Melt Curve Protocol

1. Prepare Molecular Beacon stock solution at 100 pmols/ μ l [100 μ M (micromolar)] in 1 X PCR Buffer. Gene Link provides the exact amount of nmoles of each oligo supplied on the tube and on the Oligo Report. Multiply the 'nmol' amount by 10 to arrive at the volume of solvent to be added.
2. Prepare Molecular Beacon working solution at 5 pmols/ μ l [5 μ M (micromolar)] in 1 X PCR Buffer.
3. Set up two 25 μ l reactions, one with probe alone, one with target + probe as follows.

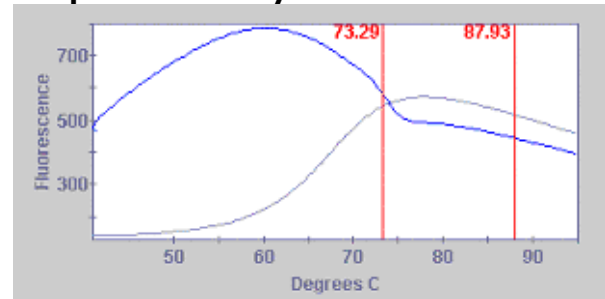
| Molecular Beacon Probe Alone | Molecular Beacon Probe plus Target |
|---|--|
| 2.5 μ l 10X PCR buffer | 2.5 μ l 10x PCR buffer |
| 3 μ l 25 mM MgCl ₂ | 3 μ l 25 mM MgCl ₂ |
| 1 μ l 5 pmol/ μ l probe [0.2 pmol/ μ l final or 200 nM] | 1 μ l 5 pmol/ μ l probe [0.2 pmol/ μ l final or 200 nM] |
| | 3 μ l 5 pmol/ μ l target [0.6 pmol/ μ l final or 600 nM] |
| 18.5 μ l H ₂ O | 15.5 μ l H ₂ O |

The protocol for Molecular Beacon Melt Curve ramps from 40 to 95 degrees C at 0.2 degrees/second

Screen capture of graphs from a Cepheid SmartCycler



Multiple Molecular Beacon Probe Alone Melt Curve



Molecular Beacon Probe plus Target and Probe Alone Melt Curve

Notes:

- MgCl₂ needs to be higher for MB reactions than for regular PCR as it helps to stabilize the stem structure of the probe during the high ramp rate. Final concentration of MgCl₂ should be between 2.5 and 4 mM. Here we use 3 mM final. This is the same range of concentration used in an actual amplification reaction.
- Final concentration of probe should be 200-600 nM. Here we use 200 nM. This is also the same concentration range used for the real time reaction.
- For a melt curve it is important to saturate the probe with target. Use 2-3 X the *Molar* amount of target. Here we use 3X target for a final concentration of 600 nM. For real time monitoring, 500 ng genomic DNA, diluted 10X to various concentrations can be used as a starting point.

QPCR

Once you have your melt curve you want to select an annealing temperature for your real time PCR where the probe alone is completely closed (shows no fluorescence), and the probe+target is completely open (shows maximal fluorescence). This temperature should be about 5-8 degrees below the T_m of the probe/target hybrid (red vertical line on melt curve of probe+target). It is important to test your primers at the annealing T to ensure that you will have strong, clean amplification at this temperature.

Signal-to-noise (S:N) ratios is calculated by dividing the fluorescence signal of a 25-mer in the presence of a two to five-fold excess of an exactly complementary target sequence by the fluorescence intensity of the probe alone.

Fluorescent Probes/Molecular Beacons Frequently Asked Questions

In a small-scale synthesis (eg. ~5-10 nmole; 2000-5000 assays), what is the amount of fluorophore-conjugated oligonucleotide typically obtained after purification?

The smallest scale of synthesis offered by Gene Link for Molecular Beacons is at the 200 nmol scale. Synthesis at the lower scale does NOT appreciably reduce cost, as cost of synthesis is NOT directly proportional to the scale of synthesis. Whereas, the higher scale affords Gene Link the ability to comfortably purify the product by polyacrylamide gel, and thus provide our customers with a product of the highest quality. **Gene Link provides between 7-15 nmols of purified product at the 200 nmols scale synthesis that is sufficient for 2000-5000 assays.**

How are these purified (eg. PAGE or HPLC)?

Answered partly above. Gene Link performs and strongly recommends gel purification and believes it to be the "gold standard" of purification. All other forms of purification depend on either hydrophobic (Reverse Phase HPLC) or ionic affinity (Ion-exchange HPLC); both of these techniques are sequence dependent and do not yield the purity achieved by gel purification. Gene Link provides a before-and-after gel picture, i.e of the crude and the gel purified oligo.

Is there mass spectroscopic confirmation of the purified product?

Not applicable. Gene Link performs gel purification and supplies a real gel picture. Molecular Beacons provided by Gene Link should have better than 50:1 signal to background ratio, usually in the range of 200. The purity is greater than 98%.

Do beacons undergo reverse complement (ie. target) verification and is a close to open ratio analysis performed?

Gene Link currently does not perform these analyses as they consider "after the fact". These analyses do NOT constitute quality of oligo synthesis but rather of design of oligonucleotide. Customers designing their probes should keep the parameters in mind. Gene Link can guide customers to the design of the stem and the loop and the Tm. A good initial reading of Fred Kramer's articles suffices the need, just as designing oligos for PCR, sequencing etc.

What fluorophores are available for conjugation?

The most popular ones are FAM, Fluorescein, HEX and TET, Cy5 and Cy3 in that order; others available as post synthesis conjugation are Alexa Series Dyes, Tamra, Texas Red, Coumarin, etc.

What quenchers are available for conjugation?

In addition to Dabcyl, BHQ-1, BHQ-2 and BHQ-3 are also available.

How quickly and in what form are fluorescent probes shipped?

Gel purified fluorescent probes are routinely shipped in 4-5 business days. These are shipped lyophilized ready to use.

What type of guarantees could be provided in the event of an inferior or incorrect fluorescent probes synthesis (eg. free replacement)?

All Gene Link products are replaced at no charge for not meeting specifications. This rarely happens. This means free replacement for the same sequence. We usually suggest designing a new probe/sequence or to avoid stretches of G" and C's etc.

Would a free fluorescent probes sample be available for testing by our laboratory?

Yes. New customers are offered, "Buy One, Get One Free" of the same fluorophore.

Would there be on-going technical support in the form of updating us on new developments in beacon synthesis?

Yes. We get to know our customers and talk frequently. The latest development is the wavelength shift, incorporating a different fluorophore in the stem in addition to the 5' end. This is similar to FRET.

Gene Link is not an "oligo factory." We believe as scientist and researchers that each oligo/probe/gene construction/genotyping etc. is an experiment to be well performed. We believe in quality, consistency and gaining confidence ourselves in our products, and ultimately gaining our customer's total confidence in Gene Link products. We hope we have answered most of the frequently asked questions. Please feel free to call (1-800-436-3546) or email (support@genelink.com) if you require more information.

Fluorophore Spectral Data

Fluorophore Absorbance and Emission Data

| Dye | Color | Absorbance max (nm) | Emission max (nm) | Extinction Coefficient |
|---------------------|---------|---------------------|-------------------|------------------------|
| 6-FAM (Fluorescein) | Green | 494 | 525 | 74850 |
| TET | Orange | 521 | 536 | 85553 |
| HEX | Pink | 535 | 556 | 95698 |
| Cy 5 | Violet | 646 | 667 | 250000 |
| Cy 5.5 | Blue | 683 | 707 | 190000 |
| Cy 3 | Red | 552 | 570 | 150000 |
| Cy 3.5 | Purple | 588 | 604 | 150000 |
| Cy 7 | Near IR | 743 | 767 | 200000 |
| Tamra | Rose | 565 | 580 | 87000 |
| ROX | Purple | 587 | 607 | 105000 |
| JOE | Mustard | 528 | 554 | 105000 |
| Alexa Dye Series | Varies | Varies | Varies | Varies |

List of Other Molecular Probes Fluorescent Dyes

| Dye | Color | Absorbance max (nm) | Emission max (nm) | Extinction Coefficient |
|--------------------|-------|---------------------|-------------------|------------------------|
| Cascade Blue | Blue | 396 | 410 | 29,000 |
| Marina Blue | Blue | 362 | 459 | 19,000 |
| Oregon Green 500 | Green | 499 | 519 | 78,000 |
| Oregon Green 514 | Green | 506 | 526 | 85,000 |
| Oregon Green 488 | Green | 495 | 521 | 76,000 |
| Oregon Green 488-X | Green | 494 | 517 | 84,000 |
| Pacific Blue | Blue | 416 | 451 | 36,000 |
| Rhodamine Green | Green | 504 | 532 | 78,000 |
| Rhodol Green | Green | 496 | 523 | 63,000 |
| Rhodamine Green-X | Green | 503 | 528 | 74,000 |
| Rhodamine Red-X | Red | 560 | 580 | 129,000 |
| Texas Red-X | Red | 583 | 603 | 136,000 |

Applied Biosystems Proprietary Dyes & Possible Substitutions

| Dye | Absorbance max (nm) | Emission max (nm) |
|-----------|---------------------|-------------------|
| VIC | 538 | 554 |
| HEX | 535 | 556 |
| NED | 546 | 575 |
| Cy3 | 550 | 570 |
| PET | 558 | 595 |
| Cy3.5 | 588 | 604 |
| ROX | 575 | 602 |
| Texas Red | 583 | 603 |

Alexa Fluor® Dyes

| Dye | Color | Absorbance max (nm) | Emission max (nm) | Extinction Coefficient |
|-----------------|---------|---------------------|-------------------|------------------------|
| Alexa Fluor 350 | Blue | 346 | 442 | 19,000 |
| Alexa Fluor 405 | Green | 401 | 421 | 34,000 |
| Alexa Fluor 430 | Green | 433 | 541 | 16,000 |
| Alexa Fluor 488 | Green | 495 | 519 | 71,000 |
| Alexa Fluor 532 | Yellow | 532 | 553 | 81,000 |
| Alexa Fluor 546 | Red | 556 | 573 | 104,000 |
| Alexa Fluor 555 | Red | 555 | 565 | 150,000 |
| Alexa Fluor 568 | Red | 578 | 603 | 91,000 |
| Alexa Fluor 594 | Red | 590 | 617 | 73,000 |
| Alexa Fluor 633 | Violet | 632 | 647* | 100,000 |
| Alexa Fluor 647 | Violet | 650 | 665* | 239,000 |
| Alexa Fluor 660 | Purple | 663 | 690* | 123,000 |
| Alexa Fluor 680 | Blue | 679 | 702* | 184,000 |
| Alexa Fluor 700 | Near IR | 702 | 723* | 192,000 |
| Alexa Fluor 750 | Near IR | 749 | 775* | 240,000 |

Spectral characteristics of the Alexa Fluor dyes. Extinction coefficient at λ max in $\text{cm}^{-1}\text{m}^{-1}$. *Human vision is insensitive to light beyond ~650nm, and therefore it is not possible to view the far-red fluorescent dyes by looking through the eyepiece of a conventional fluorescent microscope. Alexa Fluor® Dyes is sold under license from Invitrogen Corporation. These may only be used for R&D and may not be used for clinical or diagnostic use.

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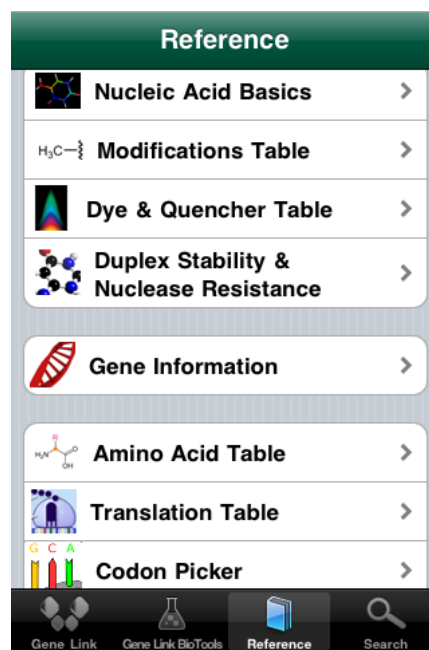
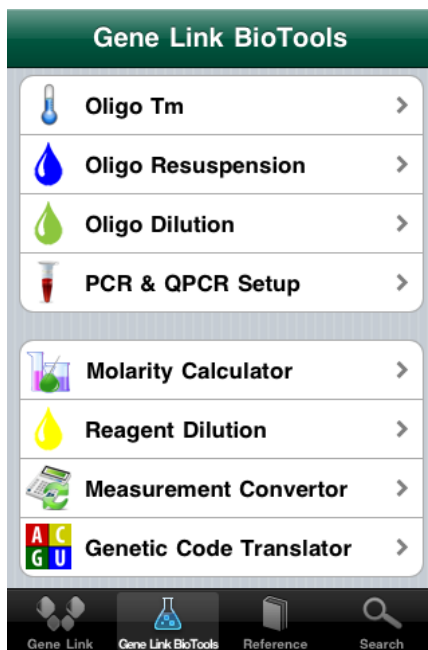
BioTools application from Gene Link for iPhone/iPod/iPad BioTools: An Array of Genetic Tools



View In iTunes

Free

Category: Education
Released: Oct 31, 2010
Version: 1.0.0
1.0.0
3.8 MB
Language: English
© Gene Link, Inc.
Rated 4+



The BioTools app also has advanced modules for setup of Polymerase Chain Reaction (PCR) and Quantitative Real Time PCR (Q-PCR).

The main focus of this app is to have a handy source of calculation modules and quick reference sections for designing and executing experiments involving PCR and Q-PCR.

| BioTools | Reference |
|---|--|
| <ol style="list-style-type: none"> 1. Oligo Tm: A robust oligo melting temperature calculation module using three methods; it also calculates other physical attributes. 2. Oligo Resuspension 5. Oligo Dilution 6. PCR & QPCR: Convenient calculator for multiple reaction setup for PCR, TaqMan QPCR and Molecular Beacon QPCR setup. Includes stock solution information and cycling profiles 7. Molarity Calculator 8. Reagent Dilution 9. Measurement Converter: A convenient selection of calculators to convert length, area, mass, temperature and volume units. 10. Genetic Code Translator: Enter DNA sequence to see coding pattern. | <p>A selection of topics, relevant to life scientists for quick access to basic information. This section includes the following sections and sub sections.</p> <ol style="list-style-type: none"> 1. Nucleic Acid Basics 2. Modifications Table: A list of common modifications with molecular structure and basic properties. 3. Dye & Quencher Table: A convenient list of fluorophores and quencher matching the emission max. 4. Duplex Stability & Nuclease Resistance 5. Gene Information: Simply enter the accession number and retrieve detailed gene information from NCBI database, 6. Amino Acid Table: Molecular structure and detailed physical properties of all amino acids. 7. Translation Table: Genetic code for all amino acids. 8. Codon Picker: Select codon sequence and see the corresponding amino acid and detailed information. |