**Multiplex PCR explainer**

**Sequencing viral genomes:** There are a variety of approaches to sequence virus genomes including metagenomics, which is ideal for virus discovery because it is an untargeted method (e.g. generated first SARS-CoV-2 genome). However, untargeted methods are usually less suited to genomic surveillance where sequencing large numbers of isolates becomes prohibitively expensive. An alternative approach is PCR-based target enrichment which produces amplicons that span the viral genome, i.e. the ARTIC multiplex PCR method. This method has been widely used for a range of viruses, including SARS-CoV-2, rabies virus, yellow fever, polio etc. It has proven robust to a large range of input titres, is highly specific and scalable to hundreds of genomes. In an outbreak situation in which isolates are highly related, and low cost per sample and rapid turnaround time are required, PCR is particularly suitable.

**Key reference:** Quick J, *et al*. Multiplex PCR method for MinION and Illumina sequencing of Zika and other virus genomes directly from clinical samples. *Nat Protoc.* 2017 Jun;12(6):1261-1276. doi: 10.1038/nprot.2017.066. Epub 2017 May 24. PMID: 28538739; PMCID: PMC5902022.

**Multiplex Polymerase Chain Reaction (mPCR)**: A technique that allows the simultaneous amplification of multiple target DNA sequences in a single reaction tube. This offers increased efficiency and throughput in various molecular biology applications. In mPCR, multiple pairs of primers are designed to target different regions of DNA in the same reaction. Each primer pair specifically binds to its respective target sequence.

**Rabies virus (RABV) mPCR primer design:** Regional primer schemes have been developed for active RABV genomic surveillance projects in Africa, Asia and South America. Primers were designed against sets of representative reference genomes found in publicly available archives like NCBI GenBank, using a primer design tool called Primal Scheme (<https://primalscheme.com/>). Due to the divergence of different RABV lineages, it is necessary to create separate schemes to capture each set of diversity in a geographic region, however multiple schemes can be combined (and tested) and efforts can be made to develop degenerate primer sets to capture a broader diversity. But, ultimately PCR is *specific* therefore if the diversity is high it may be better to consider alternative approaches like probe based capture.

**Key primer design and PCR conditions:**

These design features and reaction conditions ensure high sensitivity and reduces competitive inhibition (between primers)

* Low individual primer concentrations
* Primers have high primer annealing temperatures within a specific range (65-68 °C)
* Long annealing times
* Allows PCR to be performed as a 2-step protocol (95 °C denaturation, 65 °C combined annealing and extension)
* Alternate target genome regions are assigned to one of two primer pools, so that neighboring amplicons do not overlap within the same pool (which would result in a short overlap product being generated preferentially).
* Strategy of targeting short amplicon lengths (400bp) to help deal with potentially degraded rabies samples, which enhances the likelihood of successful amplification and whole genome capture

**Pre-workshop prep**

* Prepare “cDNA” samples as follows (one set for whole lab)
* Measure concentrations on the Quantus and record for workshop

|  |  |  |
| --- | --- | --- |
| **Desired Concentration (ng/µL)** | **Volume of Lambda DNA (µL)** | **Volume of Water (µL)** |
| 100 | 13 | 37 |
| 65 | 9 | 49 |
| 45 | 6 | 47 |
| 35 | 5 | 46 |
| 25 | 4 | 61 |
| 15 | 2 | 51 |
| 5 | 1 | 79 |
| 0 | 0 | 50 |

* Prepare 5x sets of other “reagents” (in 1.5ml tubes)

|  |  |  |
| --- | --- | --- |
| **Pretend reagent (label)** | **Use water>>>** | **Volume ul** |
| Q5 Hot Start High-Fidelity 2X Master Mix |  | 100 |
| Primer pool A |  | 50 |
| Primer pool B |  | 50 |
| Nuclease free water |  | 50 |

**Activity**

* Provide group with PCR tubes/strips, reagents and cDNA template samples.
* Guide participants through the setup of a multiplex PCR reaction, including the addition of PCR mastermix, primers, and DNA templates to the reaction tubes.
* Emphasize proper pipetting techniques, template dilution, and contamination prevention measures.
* Each participant can do a set of 8 samples i.e. 16 tubes

**Instruction**:

1. For each sample, set up two parallel individual multiplex PCR reactions, primer pool A and primer pool B, respectively

*Emphasise: The number of tubes being handled obviously increases with sample number and can become quite a lot for one person to manage. Be careful to avoid cross-contamination & mistakes.*

1. Make 2 mastermixes - for Pool A and Pool B primers. Make a mastermix that is enough for all reactions plus a 10% excess. See table below.

*Each primer will be at a final concentration of 0.015 µM in the reaction*

1. Aliquot 10μl of mastermix to PCR strip tubes for each of primer pool A and B
2. Add 2.5 μl of cDNA from step 1 to each of the primer pool A and B reactions (step 3.2)
3. Mix by gentle flicking and spin down

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | ***Per reaction*** | |  | ***Mastermix*** | |
| **Reagent** | **Pool A (μl)** | **Pool B (μl)** | **No of reactions (+ 10% excess)** | **Pool A** | **Pool B** |
| Q5 Hot Start High-Fidelity 2X Master Mix | 6.25 | 6.25 |  |  |  |
| Primer pool A | 0.75 | 0 |  |  |
| Primer pool B | 0 | 0.75 |  |  |
| Nuclease free water | 3 | 3 |  |  |
|  |  |  |  |  |

**Expected results/Learning outcomes:**

* Concentrations should match your pre-recorded Quantus measurement (+/- 3ng/ul)
* Negative control should have no reading (either <1ng/ul or unreadable)
* Emphasises importance of quality control, good lab practice and dealing with batches of samples

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| --- | --- | --- |
| 5 | 1 | 79 |
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| 100 | 13 | 37 |