



National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material[®] 2366

Cytomegalovirus (CMV) for DNA Measurements

This Standard Reference Material (SRM) 2366 is intended primarily for use in the value assignment of the number of amplifiable genome copies of cytomegalovirus (CMV) per volume, such as copies per microliter. This material is to be used to provide traceability of calibration materials used in quantitative measurements of viral load in tissues or fluids such as plasma. The DNA consists of a bacterial artificial chromosome – known as CMV Towne Δ_{147} BAC – that contains the genome of the Towne strain of CMV [1]. The three component DNA materials, labeled A, B, and C, are solubilized in TE buffer, pH 8.0, which consists of deionized water with 10 mmol/L 2-amino-2-(hydroxymethyl)-1,3-propanediol (Tris) and 1 mmol/L ethylenediaminetetraacetic acid (EDTA) tetrasodium salt. A unit of SRM 2366 consists of three sterile 0.5 mL perfluoroalkoxy (PFA) fluoropolymer vials, each vial containing approximately 150 μ L of DNA solution of each individual component.

Certified Values: Table 1 lists the certified number of amplifiable CMV genome copies for each component. These certified values were determined by digital polymerase chain reaction (PCR) using the CP1 assay [2]. The values and uncertainties of the components A, B, and C were computed using a Gaussian random effect model [3]. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [4].

Sequences: Table 2 lists the regions of the CMV genome that were sequenced. The regions that were sequenced were those used as targets in published detection methods, commercial detection methods, and one gene (UL97) which when mutated can cause resistance to treatment with ganciclovir. Sanger sequencing was performed in both the forward and reverse directions, with overlapping reads, and verified by two analysts. Users of SRM 2366 can compare the oligonucleotide primers and probes specific for their CMV PCR assays with the sequence information provided following the tables.

Expiration of Certification: The certification of **SRM 2366** is valid, within the measurement uncertainties provided, until **09 July 2013**, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see “Instructions for Use”). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet or register online) will facilitate notification.

Coordination of the technical measurements leading to the certification was under the direction of M.J. Holden and J.M. Butler formerly of the NIST Biochemical Science Division.

R.J. Haynes and M.J. Holden prepared the materials and conducted measurements. M.C. Kline and M. Coble of the NIST Biomolecular Measurements Division, and D.L. Duewer of the NIST Chemical Sciences Division provided expertise and critical review, and assistance was provided by other members of the former Applied Genetics Group of the Biochemical Science Division.

Statistical analyses were performed by B. Toman of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

Michael J. Tarlov, Chief
Biomolecular Measurements Division

Gaithersburg, MD 20899
Certificate Issue Date: 03 August 2015
Certificate Revision History on Last Page

Robert L. Watters Jr., Director
Office of Reference Materials

NOTICE AND WARNING TO USERS

Storage: All vials of SRM 2366 should be stored in the dark between 2 °C to 8 °C. **DO NOT FREEZE.**

Handling: SRM 2366 IS A VIRAL AND BACTERIAL SOURCE MATERIAL. SINCE THERE IS NO CONSENSUS ON THE INFECTIOUS STATUS OF EXTRACTED DNA, HANDLE THE SRM 2366 COMPONENTS AS BIOSAFETY LEVEL 1 MATERIALS CAPABLE OF TRANSMITTING INFECTIOUS DISEASE [5]. SRM 2366 components and derived solutions should be disposed of in accordance with local, state, and federal regulations.

INSTRUCTIONS FOR USE

Component vials should be mixed briefly and centrifuged (without opening the vial cap) prior to removing sample aliquots for analysis. For the certified values to be valid, materials should be withdrawn immediately after opening the vials and processed without delay. Dilutions of these materials may be made as appropriate, but they must be used immediately. Certified values do not apply to any material remaining in recapped vials. **DO NOT EXPOSE ANY DNA SOLUTION TO DIRECT SUNLIGHT.**

PREPARATION AND ANALYSIS

Sample Preparation: The CMV Towne^{A147} BAC was obtained from the New Jersey Medical School (Dr. Hua Zhu, Newark, NJ) and was propagated at NIST in *Escherichia coli* cells. BAC DNA was isolated, purified, and resuspended in TE buffer. After concentration adjustment, the materials were allowed to equilibrate at 4 °C in PFA containers until vialing. Just prior to vialing, each sequence was brought to room temperature inside a laminar flow hood and gently mixed. In separate sessions, each solution was transferred to sterile PFA vials with a manual pipette, which were then capped and labeled. After each production run, all vials were placed into storage at 4 °C.

Material Quantification: Quantification of SRM 2366 was accomplished using digital PCR. DNA in PCR master mix was prepared so that once the DNA solution was distributed to an array, many of the chambers had 0 or 1 copy of the amplification target. A correction to account for the chambers with more than one copy of the DNA PCR target was done using Poisson statistics. Each component of SRM 2366 was quantified separately using three randomly selected vials. Assays were conducted on each vial using 3 separate arrays (or 25 000 separate reactions). Six PCR assays targeting different regions of the CMV genome were tested and the results were not found to be significantly different. A single assay [2] targeting the CMV DNA polymerase (UL54) was used for quantification of all three components.

Sequencing: Sanger sequencing was performed and the products were separated using capillary electrophoresis. Sequence reads were analyzed by two independent analysts.

Short-Term Stability Assessment: Vials from each component were subjected to 22 °C, 37 °C, or 65 °C for a period of one to four weeks with the control at 4 °C. Isosynchronous quantitative PCR (qPCR) assays were performed at the end of 4 weeks and cycle threshold (Ct) values were analyzed. The results show that the material is stable after four weeks at 22 °C and 37 °C, but not at 65 °C.

Homogeneity Assessment: Vials were selected from each lot (100 consecutively filled vials) of each component to test for homogeneity that could be caused by bulk heterogeneity or changes during distribution of the DNA solution to vials. All tubes were assayed in triplicate using qPCR. No systematic trend between lots was observed. The random effects model [3] used to determine the values and uncertainties of the SRM components accounts for the variability between lots.

Commutability of SRM 2366: Vials of Component B of SRM 2366 were provided to Quality Control for Molecular Diagnostics (QCMD) to be included in their 2010 CMV external quality assessment (EQA) program. QCMD test materials were sent out to the CMV EQA participants. The other materials provided to participants consisted of ten lyophilized samples with different concentration of CMV virus (AD169 strain) in plasma or viral transfer medium. The NIST component B material was supplied as an unknown and came with instructions to directly add the CMV DNA to the participant's assay without extraction. A total of 179 data sets were submitted by participants for SRM 2366. Laboratory-developed assays were used to generate 80 datasets and commercial assays were used to generate 99 data sets. The results for SRM 2366 provided evidence that SRM 2366 is commutable with most assays that are in current use.

Table 1. Certified Values of the Number of Amplifiable CMV Genome Copies

Component	Value (copies per microliter)	Standard Uncertainty (copies per microliter)	Relative Uncertainty (%)	Expanded Uncertainty 95 % Confidence Interval (copies per microliter)		
A	420	56	13.3	301	to	523
B	1702	130	7.6	1446	to	1959
C	19641	365	1.8	18924	to	20359

Sequences: The nucleotide numbering is based on the Towne sequence as deposited in GenBank (AY315197.2 Human Herpes Virus 5 Towne strain). There is complete agreement between the NIST sequence and the GenBank accession, AY315197.2, with one exception at the position identified below. Table 2 lists the nucleotide ranges that were sequenced.

Table 2. Exact Nucleotide Ranges That Were Sequenced for CMV BAC.

Reference Sequences	Nucleotide Range			# Bases Sequenced
UL34	43202	to	44971	1770
UL54 ^(a)	77695	to	79992	2298
UL55 to 56	80848	to	82731	1884
UL80	114401	to	116793	2393
UL83	118890	to	119937	1048
UL97	140784	to	142090	1307
UL122 to 126	170525	to	173182	2658
UL132	176380	to	177192	813
US17	198929	to	199312	384

^(a) The sequence exception at position 78651 (UL54) is described as a Y (C/T) at NIST and a C in GenBank.

UL34 nucleotides 43202 to 44971:

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CAAAC GAAGC GTGTC TTTCA ATTTT CCCAG CGGTA CGTGG AAAGG CGGTC AGAAA ACCGC GTCCA
ACGAC ACATC CACAA AAATC CCCCC TCGAC TCTCA CAATC GCATC ATAAC CTCAG CGGGG TATGA
GCTTT CCTGT TACTT TATTC AGAAA GCACC AGAAC CCGTC GCCAT TTCCC CTCAT ATACG GTACA
CGTCC CCCTG ATCTG TCATC ACGGT ACACA GATTT CGCCC GACTG CGGAC ACCGA CGGCC AATCG
CGTGG CGTAG GAGTG GCGCC CCGGC TTCAT TATAA CGCCA CGTCG GAGCC CTGTC GCGCC ACAAC
GCCGT CCGGC GCAAC TTCTG TCTCG GCACG GTACG ATAAA AACGA CGTCC CCCGT CGAGC TTGTT
TTCTC CGAGC GGTGA TCGTT CCCGT CCCTC TCCTC CCGGC CCCCC CGGCG GCGGC CCGCT
CGCAC GGACC TATAC TATTA CCGCC CACCC CGCGT CGTCG TCATG AACTT CATCA TCACC ACCCG
AGACT TCTCC AACGA CGATT CAGTC CTGCG AGCCG CCGAG ATGCG TGACA ACGTG GCAGG CTCGA
TTTCC AAAGC GTACA AGGGT ACGGT ACGCG CCGAA GGCAA GAAGA AGCTG CTGCT GAAGC ACTTG
CCCGT GCCGC CCGGC GGCTG CTCGC GCCGC AACAG CAACC TCTTC GTTTT CTGCA CCGAG CGCGA
CTACC GCAAG TTCCA CCAGG GCATC GCACA GCTCA AGCGC GCGCC GGCCG AACTG GACCC CCACG
AGATC CAGCA AGTCA CGGCC AGTAT CCGCT GCCGC CTGCA GCCCA GTCTC CGCGA GCCGC CCACG
CCGGC CGACG AGCTG CAGAC GGCTG TGTCG CGCGT GTGCG CGCTC TTCAA CCACT TGGTT TTCAC
GGCCC AGCTG CGCCA CTACT GCGAG CACCA GGACA AGGTG GTGAG CTACG CGCGC GACGA GCTGA
CTAAA CGCTG CCGCG AAAAA TCGGC GCTGG GCGTG GAGGT GCATC AACTG GTAGC CCTGC TGCCA
CACGA GCGCC ACCGC GAACT GTGCC ACGTC CTCAT CGGCT TGTG CACCA GACGC CGCAC ATGTG
GGCGC GCTCC ATCCG TCTCA TCGGA CACCT GCGCC ACTAC CTGCA GAACA GCTTC CTACA CCTGT
TGATG AACTC AGGTT TGGAT ATCGC GCAAG TCTTC GACGG CTGTT ACCAC AGCGA GGCCT ACCGC
ATGCT CTTCC AGATC GGTCA TACGG ACTCG GTGTC GGCGG CCCTG GAACT TTCAC ACAGC GCGGC
GGCCG GGCCG CCCGA GGCCG ATGAG AACAA CGACG AAGGA GAGGA GGACG ACGAC GAGCT CCGTC
ACAGC GACCC GGCGC CGCTT CACGA GTCCA AGAAG CCCC GCAAC CCCGT CGTCC CCGCA CACGC
GTGCC GCCTC ACGAG CAAAA GCCCG AAGAA AACGA GGAGG AAGAA GAGGA GCTGT TTCCC TCCTG
CAAGG CAACC GCAGC ATTCC TGCGG GCAGA ACCCT CCGTC TCCAA CGACG ACGGC AACGG CCGCG
AACGC TGCGA CAGC TAGCG ACCCG CCTGC GGCAT TGCGC CGACG AAGAA GACGG ACCTC TAGCC
AGCCA GACCG CTGTG CGGGT CGCCG CAGCC CCCTC ACCTT CAGTC ACCCC AGCCC TTACC CCCGT
CACGT CCCCC ATAAC CCCGT TGTGT ATTTA ACGTC ACTGG AGAAC AATAA AGCGT TGATT TCTCA
AGTTC CGCTC TGGTT

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UL54 nucleotides 77695 to 79992: The sequence exception at position 78651 is enclosed in a box.

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ACTTT GAGCG CCATC TGTTC CTTGT CGAGC AACAT ACGAC GCACA GGGTC TTGAC ACTCG CGCAT
GCATT CGCGC ACGGC ACGCC GCTGC GAAAC CCACT TGTTG AGCAG TTCCG AAAGC ACCGA GACGC
GCACC GAAGC GCGCA CAAAG CGGTG GGTCA CGCCG TTCTC TAGCG TGACG CTGTA TACGT CGGCA
GGGTC CACGG GGTAC TCGCC ACCCG GCACC AACAG GGTGG AGTAG CAGAG GTTGT GGGCC ATGAT
GATGG AAGGG TAGAG GCTGG CAAAA TCGAA CACGG CCACG GGGTC GTTGT AGTAA CCCAC CTCGG
GCTCA AACAC CGTGG CACCT TGGTA CGAAA CCGCC GCGGT ACCGC CGGCG CCGTG ACTGT CGTTG
GAAAC GCCGA CGCCG CCACT ACTGC CGGAG CCGAC GCTGA AAACG CCGAC GCTGC TACTA CTGTT
ACTAC CAGAG CCGGG TGAAA CGCCG TCCTG ACTCG ACGGC GCAGA TTGCA AGGGC GGCGA CATCT
GAAAC ATAGC CGCCA CAGAA CCCGC GTCGC CGGGC ACGGC GCGCG TAGAG ATGAT AGCGG CGTTA
GGTGA CACGG CAACG CTATT CGTTT CGGGC ACCGT CGTAC CTTTG CTGTA GTGGT TGGGC AAGAT
AAAAT CGCGG CAGGC GCACT CGTCT AGCAG CGAGG TGTAG ATACG GATCT GCTGT CCGTC AAAGA
TGACA CGCCG CAACG GAATT TTAGC CAGCC GCGCG ATGGC CCCGG CCTCG TAGTG AAAAT TAATG
GTGTT GAACA GATCG CGCAC CAATA CGGCG TCCTG CAGAC AGTAA CGGCC TACCT GGGCG CGGCC
CTCGG CATTA GCCAC GAAAC AACGC GGGAT GTCCT TGTAG GACAG GTCAT CCTTG CGTTG CCGCA
GGTAA AGCTC GGCCA TAGTG TTGAG CTTAT AGTTG GGCGA GTTAG TTTG GCCAT GCATA CGGGG
TACAT GTCGA TAACC ACCGA ACCCG CAATA TACAC CTTGG TGGCG GCCGT GCTGG CCGGA TTATT
GTGAG AAGCC GAGGG AAAGG CGGCG GCGTA CTGCC GCTTA AAACC CACGG CGGGG CTGTG TAAAA
AAAAA CGGCC GCCCT GCGCC GTGGG CAACT TGCAG AAGCG CTGCG AGTCC ACCTT ATACA GGTAC
TCGAG GCGCG TGAGG ATGTA CTTCA AGTCA AAAGA GTTGA TGTTG TAACC GGTCA CAAAG GCCGG
CGCGT ACCGT TGAAA GAAAA GCATA AAGCC CAGCA GCAGC TCGTA TTCGG AAGGG AACTC GTAGA
CGTCT ACGTC TGGGC CCACC TGCCC GCAGG TGCCG ATCGT AAAGA GATGA AGACC CGAGT GCCCA
AAGAT CACGC CCTCC GAGGT GCAGC CCCGA CCATC GTTCC CGTTT GGGAT TCCCT GATCC ACGGC
GGTGT TTCCT CCCGT CTCGT AGCAC ACGCA CGAGA TCTGA ATGAC AATGT CATCA GACTT CTCGG
CGCAG GGAAA ACCAC CCTCG CCGCT CATGC ACTCG ATATC GAAGG ACAGG CACCG ATAAC GCGGC
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GACCG TCGAA CATGA CGCCT CGC

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UL55 to UL56 nucleotides 80848 to 82731:

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GAGGT CGTCC AGACC CTTGA GGTAG GGCGG CAGCG GGTCG ACTAC CTTGT CCTCC ACGTA CTTTA
CCCGC TGCTT ATACG AATTG AACTC GCGCA TGATC TCCTC GAGAT CAAAA ACGTT GCTGG AACGC
AATTC TTTCT GCGAG TAAAG TTCCA GTACC CTGAA GTCGG TGTTT TCCAG CGGGT CGATG TCTAG
GGCGA TCATG CTGTC GACGG TGGAG ATGCT GCTGA GGTCA ATCAT GCGTT TGAAG AGGTA GTCCA
CGTAC TCGTA GGCCG AGTTG CCGGC GATGA AGATC TTGAG GCTGG GAAGC TGACA TTCCT CAGTG
CGGTG GTTGC CCAAC AGGAT TTCGT TATCC TCGCC CAGTT GACCG TACTG CACGT ACGAG CTGTT
GGCGA AATTA AAGAT GACCA CTGGT CGTGA GTAGC AGCCT CCTGG CGATT CCTTC ACATT CATAT
GACGC AGCAC CTTGA CGCTG GTTTG GTTAA TGGTG ACGCA GCTGG CCAGA CCCAG GACAT CACCC
ATGAA ACGCG CGGCA ATCGG TTTGT TGTAG ATGGC CGAGA GAATA GCTGA CGGGT TGATC TTGCT
AAGTT CTTTG AAGAC CTCTA GGGTG CGCCG TTGAT CCACA CACCA GGCTT CTGCG ATTTG CGCCA
GCGCC CGGTT GATGT AACCG CGCAA CGTGT CATAG GTGAA CTGCA GCTGG GCGTA GACCA GATTG
TGCAC CGACT CCATG TTGGA TAAAT GAGTT GCATT GTTGC CATCT GTACT TCTTT TGGTT CTATT
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CAGAA GAAAA GTGAT ACGAG TCCTC GGCTT CGGAA CGAAT GGTGC GTTCC GAGGC TTCCC AGAAA
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TGAG TTGCG AAAAA TGAAA AACTT GTCGG CGTTT TCTCC AAAAT AGCTG GCATT GCGAT TAGTT
CCGTT GTAGA AAGGA GAAAT GTCAA CCACA TCACC CGTGG AAGTT GCGAA AAAAT GATAG GGATA
CTTGG AGCGC GACGT AGTGA TGGTC ACCAT ACAAT TCAGA TTACA GGTCT CACGA TAGAG CCAGG
TGCTG CCGCG GCTGT GCCAT TGATC CTTGA CCGTC ACGTA ACGGG TACTG TGGGT GTTGG AATAA

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TCGTC	GGGCA	TTAAT	TGCAT	GGTTT	TGTTT	TCATA	GCTGT	CCCTA	TGATA	AGCCA	CGAAA	ACCGT
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ACATA	GGAGG	CGCCA	CGTAT	TCCGT	GTTGC	TGCCC	AGCAG	ATAAG	TGGTG	TGGAT	GTAAG	CGTAG
CTACG	ACGAA	ACGTC	AAAAC	CTTCT	GGTAG	ACTCG	TACCT	TAAAG	GTGTG	CGCGA	CGATG	TTGCG
TTTGT	AGACC	ACCAT	GATGC	CCTCG	TCCAG	GTCTT	CATTG	ATGGG	CTTCA	TCGAG	GTGCA	GACGA
TATTA	CGTTC	AAAGC	GAATA	AGATC	CGTAC	CCTGT	GCCAT	AGAAC	ACACG	CGATA	GGGGT	ACTT

UL80 nucleotides 114401 to 116793:

CGCGC	AGTAG	CAGCG	TTTCG	AGACC	GCGGT	GAAAG	AGGAG	GACGC	AGATG	AGGCG	TACGA	TTTTG
AGTTC	TTCCA	AACGC	AGCGA	GCTCA	GCGGC	TGTCC	GCGCG	ACATC	TTCTC	GCTAA	TCTGT	AATAT
TAGAT	GATTG	CGCGA	AGTAA	AGGAG	AATTT	GCCTG	TGCGG	ACCCG	CGGGA	CGGCG	GGGTT	CTCTT
CGTCG	CGGGC	CATCA	TCGTT	CGCTC	GGTGA	GCGGG	TAGCG	ACGGT	GACGA	CAATG	ACGAT	GGACG
AGCAG	CAGCC	GCAGG	CTGTG	ACGCC	GGTCT	ACGTG	GCGCG	CTTTC	TCGCC	CGTTA	CGACC	AGTCT
CCGGA	CGAGG	CCGAA	TTGCT	GTTGC	CGCGG	GACGT	AGTGG	AGCAC	TGGTT	GCACG	CGCAG	GGCCA
GGGAC	AGCCT	TCGTT	GTCGG	TCGCG	CTCCC	GCTCA	ACATC	AACCA	CGACG	ACACG	GCCGT	TGTAG
GACAC	GTTGC	GGCGA	TGCAG	AGCGT	TCGCG	ACGGT	CTTTT	TTGTC	TAGGT	TGCGT	CACTT	CGCCC
AGGTT	TCTGG	AGATT	GTGCG	CCGCG	CTTCG	GAAAA	GTCCG	AGCTG	GTTTC	GCGCG	GGCCC	GTCAG
TCCGC	TGCAG	CCGGA	CAAGG	TGGTG	GAGTT	TCTCA	GCGGC	AGCTA	CGCCG	GCCTC	TCGCT	CTCCA
GCCGG	CGCTG	CGACG	ACGTG	GAGGC	CGCGA	CGTCG	CTTTC	GGGCT	CGGAA	ACCAC	GCCGT	TCAAA
CACGT	GGCTT	TGTGC	AGCGT	GGGTC	GGCGT	CGCGG	TACGT	TGGCT	GTGTA	CGGAC	GCGAT	CCCGA
GTGGG	TTACC	CAGCG	GTTTC	CAGAC	CTCAC	GGCGG	CCGAC	CGCGA	CGGGC	TACGT	GCACA	GTGGC
AGCGC	TGCGG	CAGCA	CTGCT	GTCGA	CGCGT	CGGGC	GATCC	CTTTC	GCTCA	GACAG	CTACG	GCCTG
TTGGG	CAACA	GCGTG	GACGC	GCTCT	ACATC	CGTGA	GCGAC	TGCCC	AAGCT	GCGCT	ACGAC	AAGCA
ACTAG	TCGGC	GTGAC	GGAGC	GCGAG	TCGTA	CGTCA	AGGCG	AGCGT	TTCGC	CTGAG	GCGGC	GTGCG
ATATT	AAAGC	GGCGT	CCGCC	GAGCG	TTCGG	GCGAC	AGCCG	CAGTC	AGGCC	GCCAC	GCCGG	CGGCT
GGGGC	GCGTG	TTCCC	TCTTC	ATCCC	CGTCG	CCTCC	AGTCG	AACCG	CCATC	TCCTG	TCCAG	CCGCC
TGCGC	TTCCA	GCGTC	GCCGT	CCGTT	CTCCC	CGCGG	AATCA	TCGCC	GTGCG	TTTCT	CCTTC	GGAGC
CGGCA	GAGGC	GGCGT	CCATG	TCGCA	CCCTC	TGAGT	GCTGC	GGTTA	CCGCC	GCTAC	GGCTC	CTCCA
GGTGC	TACCG	TGGCA	GGTGC	GTCGC	CGGCT	GTGCC	GCTCT	TAGCG	TGGCC	TCACG	ACGGA	GTTTA
TTTAC	CCAAA	GACGC	TTTTT	TCTCG	CTACT	TGGGG	CCAGT	CGCTC	GGCAG	CGCCC	GTCAT	GTATC
CCGGC	GCCGT	AGCGG	CCCCT	CCTTC	TGCTT	CGCCA	GCACC	GCTGC	CTTTG	CCGTC	TTATC	CCGCG
TCCTA	CGGCG	CCCCC	GTCGT	GGGTT	ACGAC	CAGTT	GGCGG	CACGT	CACTT	TGCGG	ACTAC	GTGGA
TCCCC	ATTAT	CCCGG	GTGGG	GTCGG	CGTTA	CGAGC	CCGCG	CCGTC	TTTGC	ATCCG	TCTTA	TCCCG
TGCCG	CCGCC	ACCAT	CACCG	GCCTA	TTACC	GTCGG	CGCGA	CTCTC	CGGGC	GGTAT	GGATG	AACCA
CCGTC	CGGAT	GGGAG	CGTTA	CGACG	GTAGT	CACCG	TGGTC	AGTCG	CAGAA	GCAGC	ACCGT	CACGG
GGGCA	GCGGC	GGACA	CAACA	AACGC	CGTAA	GGAAG	CCGCG	GCGGC	GTGCT	CGTCC	TCGGA	CGAAG
ACTTG	AGTTT	CCCCG	GCGAG	GCCGA	GCACG	GCCGG	GCGCG	AAAGC	GTCTA	AAAAG	TCACG	TCAAT
AGCGA	CGGTG	GAAGT	GGCGG	GCACG	CGGGT	TCCAA	TCAGC	AGCAG	CAACA	ACGTT	ACGAT	GAACT
GCGGG	ATGCC	ATTCA	CGAGC	TGAAA	CGCGA	TCTGT	TTGCC	GCGCG	GCAGA	GTTCT	ACGTT	ACTTT
CGGCG	GCTCT	CCCCG	CTGCG	GCCTC	TTCCT	CCCCG	ACTAC	TACTA	CCGTG	TGTAC	TCCCA	CCGGC
GATCT	GACGA	GCGGC	GGAGG	AGAAA	CACCG	ACGGC	ACTTC	TATCA	GGAGG	TGCCA	AGGTA	GCTGA
GCGCG	CTCAG	GCCGG	TGTGG	TGAAC	GCCAG	TTGCC	GCCTC	GCTAC	CGCGT	CGGGT	TCTGA	GGCGG
CAACG	GCAGG	GCCTT	CGACG	GCGGG	TTCTT	CTTCC	TGCCC	GGCTA	GTGTC	GTGTT	AGCCG	CCGCT
GCTGC	CCAAG	CCGCC	GCAGC	TTCCC	AGAGC	CCGCC	CAAAG	ACATG	GTGGA	TCTGA	ATCGG	CGGAT
TTTTG	TGGCT	GCGCT	CAATA	AGCTC	GAGTA	AGAGA	GACGC	TATAT	TTAGG	GCT		

UL83 nucleotides 118890 to 119937:

CTGCC	ATACG	CCTTC	CAATT	CGGCG	AAGAT	GCGGT	AGATG	TCGTT	GGCGT	CCCAG	AAGAA	CTCCT
GGTAC	TTCAG	ATTCT	GACCC	TGAAC	CGTAG	CCACC	ATGGG	CACCA	GGTTG	CGGGC	CAGGA	TGCCG
GCCTG	CCAGG	GCGGC	CAGGT	GAACA	CGGCC	GGATT	GTGGA	TTTCG	TTGTC	GGAAT	CCTCG	TCGGT
GTCCT	CTTCG	GGCGC	GACGG	TGGAC	TCGGC	CTTAA	GGCGG	CCGCG	TGTCA	TAACG	CCCGC	CGTGC
ACGCC	GTCGC	CGAGG	ATGCT	GATTT	GCGTT	TGCGG	CCCGC	GGAAG	TGGAG	GCGCC	CGCCA	TGGCG
CCGCC	GCCGG	TAACG	CGGGG	CGTCT	TGCGC	TCGGT	GGTTA	CGAGT	TCCTC	GTCGG	AGTCC	GATCC
GCTGG	TCCAG	ACGTC	GTCGT	CGCCC	TGGGC	GGCAC	CCTCG	TCGTG	CCGGT	CCCAG	GTGTG	TCGGT
ACTCA	AGCTT	GCCCT	GGATG	CGATA	CTGGC	TGGTG	AAGGT	GGGGT	GTTCG	CTGTA	CTGAG	GCCCG
CGCTG	CAGCA	GCAAG	TCGAT	ATCGA	AAAAG	AAGAG	CGCAG	CCACG	GGATC	GTACT	GACGC	AGTTC
CACGG	TCTCG	CGTAT	CGCTT	GCACC	TCCAG	GAAGA	TCTGC	TGCCC	GTTCA	TCAAT	AGGTT	ACCTG
AGATG	CTCAG	GCCCC	GGATG	CTCTT	GGGAC	ACAGC	AGCCC	AAAAT	GCTCG	TGTGA	GGTAA	AAGCC
ACATC	CAGCA	TGATG	TGCGA	GATCT	TGCCC	GGTTT	GATTA	TCATA	TTTTT	GGGAC	ACAAC	ACCGT
AAAGC	CGTTG	CGCTC	GTGGG	GGCGC	ATGAA	GGGTT	GCGGG	TTGCG	GGTCA	TCGTC	AGGTC	CTCTT
CCACG	TCAGA	GCCCA	GCGTG	ACGTG	CATAA	AGAGC	TTGCC	GGAGG	GCACG	TCCTC	GCAGA	AGGAC
TCCAG	GTACA	CCTTG	ACGTA	CTGGT	CACCT	ATCAC	CTGCA	TCTTG	GTTGC	GCGCG	TGTTT	TCCAT

GGAGC AAACC AGCTC GTGCG CGCAC ACCAC GTGCC GCAGT GCCAC GTCCT TGGTG GGAAA CACGA
ACGCT GAC

UL97 nucleotides 140784 to 142090:

TGCGA CCCGC GTATG TTCTT GCGCC TTACG CATCC CGAGC TCTGC GAGCT CTCTA TCTCC TACCT
GCTGG TCTAC GTGCC CAAAG AGGAC GATTT TTGCC ACAAG ATCTG TTATG CCGTG GACAT GAGCG
ACGAG AGCTA CCGCC TGGGC CAGGG CTCCT TCGGC GAGGT CTGGC CGCTC GATCG CTATC GCGTG
GTCAA GGTGG CGCGT AAGCA CAGCG AGACG GTGCT CACGG TCTGG ATGTC GGGCC TGATC CGCAC
GCGCG CCGCT GGC GAAC AGCAG CCGCC GTCGC TGGTG GGTAC GGGCG TGCAC CGCGG TCTGC
TCACG GCCAC GGGCT GCTGT CTGCT GCACA ACGTC ACGGT ACATC GACGT TTCCA CACAG ACATG
TTTCA TCACG ACCAG TGGAA GCTGG CGTGC ATCGA CAGCT ACCGA CGTGC CTTTT GACAG TTGGC
CGACG CTATC AAATT TCTCA ATCAC CAGTG TCGTG TATGC CACTT TGACA TTACA CCCAT GAACG
TGCTC ATCGA CGTGA ACCCG CACAA CCCC A GCGAG ATCGT GCGCG CCGCG CTGTG CGATT ACAGC
CTCAG CGAGC CCTAT CCGGA TTACA ACGAG CGCTG TGTGG CCGTC TTTCA GGAGA CGGGC ACGGC
GCGCC GCATC CCAA CTGCT CGCAC CGTCT GCGCG AATGT TACCA CCCTG CTTTC CGACC CATGC
CGCTG CAGAA GCTGC TCATC TGCGA CCCGC ACGCG CGTTT CCCC TAGCC GGTCT ACGGC GTTAT
TGCAT GTCGG AGCTG TCGGC GCTGG GCAAC GTGCT GGGCT TTTGC CTCAT GCGGC TGTG GACCG
GCGCG GTCTG GACGA GGTGC GCATG GGCAC GGAGG CGTTG CTCTT TAAGC ACGCC GCGCG GGCCT
GCCGC GCGTT GGAGA ACGGC AAGCT CACGC ACTGC TCCGA CGCCT GTCTG CTCAT TCTGG CCGCG
CAAAAT GAGCT ACGGC GCCTG TCTCC TGGGC GAGCA TGGCG CCGCG CTGGT GTCGC ACACG CTGCG
CTTTG TGGAG GCCAA GATGT CCTCG TGTCG CGTAC GCGCC TTTCC CCGCT TCTAC CACGA ATGCT
CGCAG ACCAT GCTGC ACGAA TACGT CAGAA AGAAC GTGGA GCGTC TGTG GCCAC GAGCG ACGGG
CTGTA TTTAT ATAAC GCCTT TCGGC GCACC ACCAG CATAA TCTGC GAGGA GGACC TTGAC GGTGA
CTGCC GCCAA CTGTT CCCC AGTAA CCGGG ACGCG GAACG TGACG GTTGC TGAGG GGAAA GCGCA
CAGAG AA

UL122 to UL126 nucleotides 170525 to 173182:

CAGCA CCATC CTCCT CTTCC TCTGG GGCAA CTTCC TCTAT CTCAG ACACT GGCTC AGACT TGACA
GACAC AGTGT CCTCC CGCTC CTCCT GAGCA CCCTC CTCCT CTTCC TCATC ACTCT GCTCA CTTTC
TTCCT GATCA CTGTT CTCAG CCACA ATTAC TGAGG ACAGA GGGAT AGTCG CGGGT ACAGG GGAAT
CTGGG GGTGA CACCA GAGAA TCAGA GGAGC TGGCA CCAGC GGTGG CAAA GTGTA GGCTA CAATA
GCCTC TTCCT CATCT GACTC CTCGG CGATG GCCCG TAGGT CATCC ACACT AGGAG AGCAG ACTCT
CAGAG GATCG GCCCC CAGAA TGTAC TGGGC AAAGA CTTTC ATGCA GATCT CCTCA ATGCG GCGCT
TCATT ACACT GATAA CCTCA GGCTT GGTTA TCAGA GGCCG CTTGG CCAGC ATCAC ACTAG TCTCC
TCTAA GACAT AGCAG CACAG CACCC GACAG AACTC ACTTA AGAGA GAGAT GCCCC CGTAC ATGGT
CATCA TACAA GCGTC ACTAG TGACC TTGTA CTCAT TACAC ATTGT TTCCA CACAT GTAGT GAGGA
TATCC ATAAA TATGT GATCA ATGTG CGTGA GCACC TTGTC TCTCT CCTCA TCCAA AATCT TAAAT
ATTTT CTGGG CATAA GCCAT AATCT CATCA GGGGA GCACT GAGGC AAGTT CTGCA ATGCC GCCAT
GGCCT GACTG CAGCC ATTGG TGGTC TTAGG GAAGG CTGAG TTCTT GGTAA AGAAC TCTAT ATTCC
TGTAG CACAT ATACA TCATC TTTCT CCTAA GTTCA TCCTT TTTAG CACGG GCCTT AGCCT GCACT
GCACC CCCC ACTTG TTAGC GCGCG CCTTG CTCAC ATCAT GCAGC TCCTT AATAC AAGCC ATCCA
CATCT CCGC TTATC CTCAG GTACA ATGTA GTTCT CATACT ATGCT CTGCA TAGTT AGCCC AATAC
ACTTC ATCTC CTCGA AAGGC TCATG AACCT TATCT AAGAT ATCTA AGGCA TTCTG CAAAC ATCCT
CCCAT CATAT TAAAG GCGCC AGTGA ATTTC TCTTC CGTCT GGGTA TATTT TTTCA GCATG TGCTC
CTTGA TTCTA TGCCG CACCA TGTCC ACTCG AACCT TAATC TGTTT GACTG TAGAG GAGGA TAACA
ACACA TATAA GTATC CGTCC TCCTG ACTCA TTTAT CGCTA TCTCG ATGCC CCGCT CACAT GCAAG
AGTTA ATCTT TACTC TATCT GACAT ACACA AGTAA ATCCA CGTCC CATGC AGGTT AGTAT ACATC
ACATA CATGT CAACA GACTT ACCGA GTTCT GCCAG GACAT CTTTC TCGGG GTTCT CGTTG CAATC
CTCGG TCACT CGTTC AAAAG TTTTG AGGGA TTCTT CCGCC AACTC TGGA ACAGC GGGTC TCCCA
GACTC AGCTG ACTGT TAACC TCCTT CCTCA ACATA GTCTG CAGGA ACGTC GTGGC CTTGG TCACG
GGTGT CTCGG GCCTA AACAC ATGAG AAATA GAGTC ATAAG CACAT GGGTC ACATA CAGGA GATAT
GTATA TAACA TTAAT ACAAT TTTAT AAAAA AAAGG GGGGG CACAA ACCCC GACAC GTACC GTGGC
ACCTT GGAGG AAGGG CCCTC GTCAG GATTA TCAGG GTCCA TCTTT CTCTT GGCAG AGGAC TCCAT
CGTGT CAAGG ACGGT GACTG CAGAA AAGAC CCATG GAAAG GAACA GTCTG TTAGT CTGTC AGCTA
TTATG TCTGG TGGCG GCGCG GGCAG CAACG AGTAC TGCTC AGACT ACACT GCCCT CCACC GTTAA
CAGCA CCGCA ACGGG AGTTA CCTCT GACTC TTATC AGAAT ACAAC AACTC AGCTG CCTGC ATCTT
CTTCT GCCGC TGCC TAAAGT CTTCC ATCTG CGTCA GCGGT GCGAG CCCAA TCTCC GAGCT CATTT
TCAGA CACAT ACCCT ACCGC CACGG CTTG TGGCG CACAC TGGTG GTGGT GGGCA TTGTG CTGTG
CCTAA GTCTG GCCTC CACTG TTAGG AGCAA GGAGC TGCCG AGCGA CCATG AGCCG CTGGA GGCAT
GGGAC CAGGG CTCGG ATGTG GAAGC TCCGC CGCTA CCGGA GAAGA GCCCA TGTCC GGAAC ACGTA
CCCGA GATTG GCGTG GAGAT CCCAC GCTAT GTTTA ATAAA AACTG CGGGC ACGGG GGACG GCGTT
GTTGT ATATG TGAAT TTGTA AATAA TAAAT GGGAC CCCAT CCTGT AAAAA TACAG AGTCC GTGTC

AGTCT CTGAA GGACA GAGTA TTGGC ATATA GCCAA TAGAG ATAGT TGTGG CAAAG AGCCA TGTTA
TGGAT TAGTA ATGGA AAGTA TCGTC ACCAA TAGGG GAGTG GTCAA TAATG GTCAA TAACC CACAC
CTATA GGCTA AGCTA TACCA TCACC TATAG CATAA GGAAG CGGGG GTGTA TAGGC CCCAA GCCAA
AAACA GTATA GCATG CATAA GAGCC AAAGG GGTGT GCCTA TAGAG TCTAT AGGCG GTACT TACGT
CACTC TTGGC ACGGG GAATC CGCGT TCCAA TGCAC CGTTC CCGGC CGCGG AGGCT GGATC GGTCC
CGGTG TCTTC TATGG AGGTC AAAAC AGCGT GGATG GCGTC TCCAG GCGAT CTGAC GGT

UL132 nucleotides 176380 to 177192:

CTAGT CGTAC TCGGG ATCTC TGAGC GAGAC GGGTT GCATG GCAAC TTTCA TTAGT TTGGG AATCT
GCCAG CTGGT GCTGT TCGAA GGTTC TTCCA TTTCC GAGGC GTTCA TCGTA CACCG AAACG
TAGTA CTTGA TGGGG TCCTC CTCAT TGTCC GAGAG GTGAG ATTCG ATGGT CAAAG GCGAG CCTCT
CCCAT AATTG GGATT CACGA ACGAC GTGTC CAAGT TGCCA TCCTT TCTGA AATAG ATGAC GTTCT
CAGGA TCATG TTTCA TCGCG TCGCG GGCCG CGGAC GCCTC CTCCT CCTCG TCCCA GTCCC GAGTT
TCCAA CCGCT GATAA GGGCT CGAGG AACAA AATCC GCGCG GGATC TGAGA ACCTC GTCGG GAACC
GCTGC CAAAC GGGCT GCTGC CGCCA CTGTC GTCCG TGTCG TCCAA CAGGT TGACG GCCTC TTCGT
CGGCG AAACG AAAGC GGCCC GGGTG CTTGC AACAC GAGGA GTAAA CTACC GCGAT CAGTA CCGCT
ATGAA GCTGA AAATG GAGGT GCCTG TCACG ATGTA GAAGA GGATA GCCAG CACTT TCATG ATTTC
GTCAT TCGCG GCGTC GTGAA CGGAA GATTC GCGGG CGGTG GTCAT GTTGG TTTCT GTTGT AGGTT
CGCTA CTCGT GGTGC TCTCG ACGGT ATTTT TGCTG CTGGT GCTAG TAGGG ACGTT TGTGC TGCTG
GTCAT ATTTT TAGCG TCGCT GAAGT CGATG TGAAG CAGCA ACCCG AACGC GACCA GGACC AGGAA
TGTTG CGCGA AGGAG ACCCC GCGGG GCCGG CAT

US17 nucleotides 198929 to 199312:

TCATA GAGAC ACAAG GTGAG CAGGT CGGCC TCGGA CCACG CGATC TCAAA CAGGC GCGTG GTGTC
AAAGA CCGTG ACGAC CAGCA TGAAG CTGAG CGCCA TGGCG TAATA GCCCA AAAAA AGTTT GTGCC
CTAAC GGTAC GGGTT GCAGG TAAAG TGCGA TCAAG AACGC GATAA CGCCG ATCAC AAACA GCGTG
ATGAT GACCT GCCAT CGACG GTGAT TATGG GCGGC TAGAC CCGTG ACGCA GCTGC AGAGG CTAAG
AAGCA CGCAA GCCAA GAGGC CCGAG AAGGT CACCA GCGTA GAGGA GGAGC AGGCG CTGGC CACGA
TCACC GAAAG CGTCG TGAGC ACGCT GTAAA TGGTG AGCAG GCCCG GGCTC GGCGG CGAC

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