***CAFE MOCHA*: An Integrated Platform for Discovering Clinically Relevant Molecular Changes in Cancer; an Example of Distant Metastasis and Recurrence-linked Classifiers in Head and Neck Squamous Cell Carcinoma**

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Abstract

Background

CAFE MOCHA (Clinical Association of Functionally Established MOlecular CHAngeS) is an integrated GUI-driven computational and statistical framework to discover molecular signatures linked to a specific clinical attribute in a cancer type. We tested *CAFE MOCHA* in head and neck squamous cell carcinoma (HNSCC) for discovering a signature linked to distant metastasis and recurrence (MR) in 517 tumors from TCGA and validated the signature in 18 tumors from an independent cohort.

Methods

The platform integrates mutations and indels, gene expression, DNA methylation and copy number variations to discover a classifier first, predict an incoming tumour for the same by pulling defined class variables into a single framework that incorporates a coordinate geometry-based algorithm, called Complete Specificity Margin Based Clustering (CSMBC) with 100% specificity. *CAFE MOCHA* classifies an incoming tumour sample using either a matched normal or a built-in database of normal tissues. The application is packed and

27 deployed using the *install4j* multi-platform installer.

28 **Results**

29 We tested *CAFE MOCHA* to discover a signature for distant metastasis and recurrence in
30 HNSCC. The signature MR44 in HNSCC yielded 80% sensitivity and 100% specificity in
31 the discovery stage and 100% sensitivity and 100% specificity in the validation stage.

32 **Conclusions**

33 *CAFE MOCHA* is a cancer type- and clinical attribute-agnostic computational and
34 statistical framework to discover integrated molecular signature for a specific clinical
35 attribute.

36
37 *CAFE MOCHA* is available in GitHub (<https://github.com/binaypanda/CAFEMOCHA>).

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39 Key Words: mutation, methylation, gene expression, copy number variation (CNV),
40 sensitivity, specificity and integrated platform.

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45 **Introduction**

46 Cancer progression is linked to molecular changes at multiple levels, such as
 47 somatic mutations, gene expression, DNA methylation and copy number changes. In the
 48 last 5yrs, a large amount of data on key variants in multiple cancers has been generated
 49 by international consortia, like The Cancer Genome Atlas (TCGA) (Editorial, 2015;
 50 Weinstein *et al*, 2013), International Cancer Genome Consortium (ICGC) (Hudson *et al*,
 51 2010) and individual laboratories, aiding our understanding of various cancers at molecular
 52 level. Utilizing the vast amount of molecular data from studies on tumour genomes,
 53 exomes, transcriptomes and methylomes, and linking those with data from genetic and
 54 functional studies will help find clinically relevant insights. Although there are existing
 55 databases and studies that combine molecular changes across cancer types (Deng *et al*,
 56 2016; Huang *et al*, 2015; Netanelly *et al*, 2016), studies linking the events explicitly within
 57 the same tumour type across a large number of samples to predict signatures for a
 58 specific clinical attribute are currently lacking.

59 Here, we describe a cancer type-agnostic computational and statistical framework
 60 with a user-friendly graphical-user-interface (GUI) to discover integrated signatures using
 61 six tumour-specific event types; somatic mutations and indels (mut), DNA copy number
 62 changes (cnv), gene expression changes (expr), 5-cytosine DNA methylation changes
 63 (meth), functional copy number changes (fcnv, where CNVs are linked to gene expression
 64 changes) and functional *cis*-regulatory DNA methylation changes (fmeth, where hyper-
 65 and hypo-methylation result in down- and up-regulation of effector gene expression
 66 respectively). *CAFE MOCHA*, in addition to classifying categorical events like mut and cnv,
 67 uses an algorithm called Complete Specificity Margin Based Clustering (CSMBC) to
 68 classify quantitative (expr and meth) and coupled events (fmeth and fcnv), and combines
 69 the event types using sample frequency and event priority filters, to produce integrated

signatures describing the clinical variable with 100% specificity. We tested *CAFE MOCHA* to discover a signature linked with distant metastasis and recurrence in head and neck squamous cell carcinoma (HNSCC) using 434 tumours from TCGA as a discovery cohort, which was validated in an independent cohort of 18 tumours. The integrated signature MR44 for metastatic and recurrent tumours in HNSCC (MR44) yielded a sensitivity of 79.52% and a specificity of 100% in the discovery cohort and with 100% sensitivity and 100% specificity in the validation cohort.

Materials and Methods

Discovery module

CAFE MOCHA application workflow and the GUI are illustrated in Figure 1. *CAFE MOCHA* has two independent modules, discovery and prediction. In the discovery module, both somatic mutations (missense, nonsense and splice-site) and indels were considered under mut. A matrix of following values (thresholds) were considered for cnvs; -2: full copy deletion, -1: allelic deletion, 1: low-copy amplification, 2: high-copy amplification, and 0: lack of any copy number variation. For expression and methylation, RSEM (Li & Dewey, 2011) -normalized gene-wise intensity matrix and a probe-wise matrix of pre-processed β values (from Illumina 450k whole-genome methylation arrays), respectively, were used. The methylation data was pre-processed, including normalization and batch correction, as described previously (Krishnan *et al*, 2016). Tumour samples assayed for all the four events (mut, cnv, expr and meth) were considered for the discovery phase. The perturbed genes were passed through a functional filter (detailed below) before being used in the integrated analysis. In the case of methylation data, a sub-region filter was applied and only probes located in the gene promoters, transcription start site (TSS200 and TSS1500) and CpG islands were retained. Categorical events like mut and cnvs were linked to the

chosen clinical attributes with complete specificity. Quantitative events such as expression (expr) and methylation (meth) were linked to clinical attributes using an algorithm called Complete Specificity Margin Based Clustering (CSMBC) algorithm (detailed below). A somatic filter based on an unpaired t -test ($P < 0.05$) was further used to retain only tumour-specific expr and meth events. Expression events were further coupled with meth and cnvs to generate coupled events (fmeth and fcncv) respectively, where meth and cnvs affected the target gene expression. We only considered hyper- and hypo-methylation events linked with the down- and up-regulation of downstream gene expression respectively.

Data integration and making of the final signature

Using the 'integrate' feature, the individually discovered events were combined into an integrated signature with two different filters (Figure 1B). In the first, a tumour-specific sample frequency-based filter agnostic to any event type was applied. In the second, all event types' priorities were determined by detection sensitivity first and then those events that yield highest priority followed by highest sample frequency were chosen. These two filters work contrarily, one retaining the high sample frequency quantitative and semi-quantitative event types (expr, meth, fmeth, fcncv) and another the lower-sample frequency categorical and semi-categorical event types (mut, cnv, fcncv). Selected events were considered for removal of false positives using samples lacking complete cross-platform overlap from TCGA and the independently provided datasets (used for confirmation in the second stage of the discovery stage). The number of confirmed events was further minimized using the sample frequency-based filter to constitute the discovery panel for that specific clinical attribute. This minimal signature is then subjected to an independent validation using tumours assayed for all the four events (mut, cnv, expr, meth) (Figure 1B). Finally, the discovered events were mapped to all of the sixteen cancer-related pathways

from KEGG (Kanehisa *et al*, 2002; Kanehisa *et al*, 2004; Kanehisa *et al*, 2012)
(hsa05200).

CAFE MOCHA Interface

The interface for *CAFE MOCHA* was developed and deployed using *Netbeans IDE v 8.1* (<https://netbeans.org/downloads/>). The Graphical User Interface (GUI) was designed using JAVA AWT (<http://www.javatpoint.com/java-awt>) with SWING components (<http://www.javatpoint.com/java-swing>) with its native OS GUI and appropriate controls. The back end for this interface was built on a Linux-dependent platform with *R*, *BASH*, *BEDTools* (v2.3) and *PERL* as added dependencies. *CAFE MOCHA* requires installations of *R* package dependencies (minfi v1.18.2 (Aryee *et al*, 2014), waterRmelon v1.16.0 (Pidsley *et al*, 2013), IlluminaHumanMethylation450kmanifest v0.4.0, randomForest v4.6.12 (Breiman, 2001), varSelRF v0.7.5, pheatmap v1.0.8, gplots v3.0.1, ggplot2 v2.1.0, reshape2 v1.4.1) to pre-process 450k *idat* files and generates the matrix of β values. The platform provides the user with an option to install the dependencies. Under the discovery module, mut, cnv, expr and meth data can be browsed and acquired locally.

Functional filters

To ensure functional relevance of predicted tumour-specific molecular changes, we introduced various filters for different events to select genes of interest. We used IntOGen (Gundem *et al*, 2010) to select driver/potential driver mutations, MethHC (Huang *et al*, 2015) for known hyper- and hypomethylated genes in different cancer types, G2SBC (Mosca *et al*, 2010) for selecting important differentially expressed genes associated with breast cancer, The Human Protein Atlas (Uhlen *et al*, 2015) for functional proteins, the dbDEPC 2.0 database (He *et al*, 2012) for manually curated differentially expressed

proteins in human cancer and miRTarBase (Chou *et al*, 2016; Hsu *et al*, 2011; Hsu *et al*, 2014) for experimentally validated miRNA-target gene associations. In the case of micro-RNA methylation, we considered those events where methylation of a microRNA correlated with a concomitant expression change in one or more of its target gene(s). In the case of fcny, we considered where amplification and deletion in a gene was linked to its up- and down-regulation respectively in tumour sample compared to normal. Only full copy deletions (not allelic deletions) and amplifications were considered. Genes bearing categorical events in at least one sample that passed the functional filter were considered further.

Complete Specificity Margin Based Clustering (CSMBC)

We devised a statistically framework, Complete Specificity Margin Based Clustering or CSMBC, for inferring the expression and the methylation boundaries of each cluster for a specific clinical attribute (Figure 2). In CSMBC, the number of clusters were fixed equivalent to the number of pre-defined clinical variables. For each cluster, axis-perpendicular boundaries passing through the most extreme outliers on the expression/methylation coordinate axes were determined first. The number of overlaps was dependent upon the number of boundaries. In the simplest case, there can be two sub-categories. For example, metastasis as a category has two sub-categories, metastatic (A); and non-metastatic (B). In this simplest case, there can only be one overlap ($A \cap B$). Likewise, if a clinical attribute has three (A, B and C) sub-categories (for example recurrent, non-recurrent, can't be defined) with four possible overlaps ($A \cap B, A \cap C, B \cap C, A \cap B \cap C$). Using the above logic defined for categories and sub-categories, all possible overlaps between clusters were identified first, and then the minimum and maximum values for various overlaps were estimated according to the following equations:

173

174 For overlap between two sub-categories:

$$175 \quad i \cap j_{\min} = \max(i, j); i \cap j_{\max} = \min(i, j)$$

176

177 For overlap between three sub-categories:

$$178 \quad i \cap j \cap k_{\min} = \max(i, j, k); i \cap j \cap k_{\max} = \min(i, j, k)$$

179

180 For overlap between four sub-categories:

$$181 \quad i \cap j \cap k \cap l_{\min} = \max(i, j, k, l); i \cap j \cap k \cap l_{\max} = \min(i, j, k, l)$$

182

183 A sample was identified to be within 100% specificity margin of the cluster if it was not
184 in any region of overlap with other clusters (Figure 2). The total number of all such
185 samples, i.e., sensitivity of that cluster, was estimated according to the equation below:

186

187 For two sub-categories:

$$188 \quad \text{sensitivity}_i = n_i - n_{i \cap j}$$

189 For three sub-categories:

$$190 \quad \text{sensitivity}_i = n_i - n_{i \cap j} - n_{i \cap k} + n_{i \cap j \cap k}$$

191 For four sub-categories:

$$192 \quad \text{sensitivity}_i = n_i - n_{i \cap j} - n_{i \cap k} - n_{i \cap l} + n_{i \cap j \cap k} + n_{i \cap j \cap l} + n_{i \cap k \cap l} - n_{i \cap j \cap k \cap l}$$

193

194 Finally, an unpaired *t*-test was performed between all tumour and all normal samples,
195 and genes/probes with significantly different expr/meth values ($P < 0.05$) between the
196 tumour and normal groups were retained.

197

198 *Prediction module*

199 The prediction module has two options: one, where the user provides somatic
200 mutations/indels, tumour-specific expr, meth and cnv information, and second, where the
201 user has somatic mutations/indel/cnv data but does not have expr and meth data from the
202 matched normal samples. In the later case, *CAFE MOCHA* uses a built in normal
203 database (all normal samples from the TCGA for a particular cancer type) to compute
204 expression and methylation values for genes in control samples from RNASeq for
205 expression and whole genome arrays (Illumina 450k) for DNA methylation. For the
206 prediction module, the data is entered as per the pre-defined format (same as discovery
207 panel) specific to a cancer type and clinical attribute of interest (Figure 1). Based on the
208 user input, coupled events (fmeth and fcnv) are determined and used for the prediction
209 module.

210

211 *Testing CAFE MOCHA to discover metastatic/recurrent HNSCC signature*

212 We tested *CAFE MOCHA* to discover integrated signature for metastatic and recurrent
213 HNSCC tumours using tumours from TCGA dataset (n=434), followed by confirmation
214 (removal of false positives, the second stage of the discovery phase) using two sample
215 cohorts, 42 samples from TCGA and 37 samples from an independent cohort (Krishnan *et al*
216 *al*, 2015; Krishnan *et al*, 2016), where the information on at least one of the event type out
217 of the 4 events (mut, cnv, expr and meth) for the same tumour was available (Table 1,
218 Supplementary Tables S1 and S2). Finally, the discovery panel was validated in 18
219 samples from an independent sample cohort (Krishnan *et al*, 2015; Krishnan *et al*, 2016),
220 where all the four events were assayed for all the tumours (Supplementary Table S3). For
221 the discovery module, we downloaded the Broad automated somatic mutations and indel
222 call file, copy number data with gistic2 threshold, Illumina HiSeqV2 RSEM (7) -normalized
223 RNA-seq gene expression data, 450k DNA methylation data and the clinical data from the

224 UCSC Xena Browser (<http://tinyurl.com/jhmg9b9>). The distant metastasis (M1) and
225 recurrent tumours (RFS_IND = 1) were compared with non-metastatic (M0) and non-
226 recurrent (RFS_IND = 0) tumours to derive a specific signature.

227

228 **Results**

229 *Discovery of distant metastasis/recurrence-associated molecular signature MR44 in*
230 *HNSCC*

231 *CAFE MOCHA* identified a total of 6649 events from individual event type discovery (8
232 somatic mutations, 1436 cnvs (506 amplifications and 982 full copy deletions), 1098
233 expression-related events, 4018 methylation events, 27 fcnv events (8 high copy
234 amplifications and 19 full copy deletions) and 62 fmeth events), associated with metastasis
235 and recurrence in HNSCC. Integration across discovered events was performed using two
236 filters as described in the Methods section. The filters resulted in 79 (22 expression-related
237 events and 57 methylated genes) and 171 (7 mut, 84 cnvs (46 amplifications and 38 full
238 copy deletions), 24 expr, 2 meth, 25 fcnv events (8 high copy amplifications and 17 full
239 copy deletions) and 29 fmeth events) events, individually, and 232 (7 mut, 84 cnvs (46
240 amplifications and 38 full copy deletions), 30 expr, 57 meth, 25 fcnv events (8 high copy
241 amplifications and 17 full copy deletions) and 29 fmeth events), cumulatively after
242 removing any redundancy (Supplementary Table S4).

243

244 Using data at the second stage of the discovery phase (confirmation stage), 98 false
245 positives events were eliminated. The remaining 134 events (Supplementary Figure S1)
246 (5 mut, 83 cnvs (46 amplifications and 37 full copy deletions), 8 expr, 9 meth, 24 fcnv
247 events (8 high copy amplifications and 16 full copy deletions) and 5 fmeth events) were
248 further minimized to a final discovery panel of 44 events (MR44) that included 2 mut, 15
249 cnvs (3 amplifications and 12 full copy deletions), 8 expr, 9 meth, 8 fcnv events (5 high

copy amplifications and 3 full copy deletions) and 2 fmeth events) (Figure 3A). The signature was further validated using an independent cohort of 18 samples (3 M1/R and 15 non-MR) of an independent oral tongue squamous cell carcinoma (OTSCC) cohort, with 100% sensitivity and 100% specificity. 17 out of the 44 events in MR44 signature were validated in at least one sample in the validation cohort (Figure 3B).

Power of integration

We wanted to investigate the power of integration (where all the six different event types were used to derive the signature) over lesser order combinations or with individual event type, in terms of the detection sensitivity and the number of events required to achieve maximum specificity. As shown in Figure 4, the detection sensitivity showed a gradual enhancement when the number of event types increased from one to six. For single-event analyses, meth and both mut and fmeth provided with a maximum and minimum sensitivity respectively (37%, 7%, Figure 4A). The number of CNVs required to achieve the highest possible level of sensitivity in a single-event analysis was the highest (83 events with 33% sensitivity). When using more than one event type, we obtained an increase in sensitivity to various levels gradually from a single-event to a six-events signature (Figure 4). The number of CNVs and both mut and fmeth required to get similar level of sensitivity was highest and lowest respectively for all combinations. Highest sensitivity (80%) of detection was observed when all the six different event types were used to produce the integrated signature (Figure 4F). The impact of event integration on detection sensitivity was observed to be greatest when the integration was performed in the following order: meth + cnvs + expr + fmeth + fcns + mut. Each incremental integration in this order caused a gradual increase in sensitivity (37.35 → 56.63 → 68.67 → 74.70 → 77.11 → 79.52, Figure 4). The actual events for all combinations and individual event type analyses are illustrated in Supplementary Figure S1.

276

277 Discussion

278 Integrating multiple molecular events is a strategy proposed to identify master
 279 regulators in cancer (Gevaert & Plevritis, 2013; Thingholm *et al*, 2016). However, a
 280 meaningful integration should be incremental, with each level filtering out the unnecessary
 281 and only retaining the functionally relevant associations. Furthermore, integration of data
 282 should link a specific signature to clinically relevant tumour attributes in order for making
 283 meaningful conclusions. Integrated analyses often fail to establish the link between
 284 cancer-associated changes within the same tumour types across cohorts, perhaps due to
 285 the low overlapping of clinical characteristics across cohorts and low reproducibility of
 286 results across laboratories, geographies and discovery platforms. Additionally, data on
 287 multiple events; genetic, transcriptomic and epigenetic changes, from the same sets of
 288 tumour:matched normal samples are often not available , making it difficult to discover
 289 truly integrated signatures. Nevertheless, such a discovery set, where all the events are
 290 assayed for all tumour:normal pairs within the same cohort, is functionally more
 291 meaningful. As multidimensionality increases with the availability of more data, especially
 292 from the large consortia like TCGA and ICGC, it will become imperative to design and
 293 implement easy-to-use and robust web-based platforms to discover (using a pre-defined
 294 training set) multi-gene and multi-platform classifiers for a particular clinical attribute and
 295 predict the same for an incoming new tumour sample. Currently, such a platform is lacking
 296 that can discover tumour-specific genome-wide functional and somatic molecular changes
 297 linked to a specific clinical attribute, using a sizeable multi-dimensional dataset. Keeping
 298 this in mind, we devised *CAFE MOCHA*, an automated and integrated framework to
 299 discover meaningful, functional and somatic molecular changes in a cancer type that links
 300 the signature(s) to a specific clinical attribute. *CAFE MOCHA* is designed to use both user-
 301 defined/generated and publicly available tumour and matched normal data.

302

303 Additionally, the prediction module of *CAFE MOCHA* uses a backend database of
304 unmatched normal samples to increase the prediction scope of the tool for tumours where
305 matched normal samples are not available, especially where expression and methylation
306 data is not available from matched normal samples. *CAFE MOCHA* is a cancer type- and
307 clinical attribute-agnostic tool and has the ability to pull data on several event types under
308 a single framework. *CAFE MOCHA* classifies events into three different types, categorical
309 (mutations and CNV), quantitative (expression and methylation) and coupled/linked
310 (functional CNVs and functional methylation) and uses an algorithm called complete
311 specificity margin based clustering (CSMBC), a fully supervised approach, to identify
312 clinically linked quantitative and coupled events. CSMBC is a modification of the Large
313 Rectangle Margin Learning (LRML) approach described previously (Kirmse & Petersohn,
314 2011) and is conceptually similar to fast boxes which take the 'characterize' and then
315 'discriminate' approach of classification (Goh & Rubin, 2014). The input for CSMBC is a
316 continuous function spread across a single dimension, either expression or methylation.
317 For both these variables, an unsupervised clustering, which requires *a priori* knowledge of
318 the quantitative expression or methylation map, is not feasible since these are continuous
319 variables. The selection of boundary margins, according to the chosen clinical variables on
320 the other hand does not require any prior knowledge of the quantitative spread of these
321 events. Additionally, supervised clustering is faster than unsupervised clustering since it
322 does not require iterative computing and does not require re-estimation of the cluster
323 mean. Nevertheless, as pointed out in the past (Richards, 2013), a hybrid semi-supervised
324 approach that uses the results of an unsupervised approach such as the *k*-means or
325 Expectation Maximization (EM) as training areas for a supervised classification, might
326 combine the advantages of both supervised and unsupervised classification approaches.
327 A weighted sensitivity method (Gao, 2007; Iwamoto & Pusztai, 2010) that weighs the

328 classification sensitivity of a sample based on its proximity to the nearest boundary, would
 329 further add confidence perhaps at the cost of sensitivity, particularly while predicting the
 330 clinical status of an incoming sample. While we plan to develop *CAFE MOCHA* taking
 331 these modifications into account in the future, the current implementation benefits from
 332 ensuring complete specificity for each clinical attribute-associated molecular event. One of
 333 the limitations of CSMBC is that its specificity is entirely dependent on the denominator,
 334 *i.e.*, sample numbers and therefore, may be sub-optimal in a scenario where fewer
 335 numbers of tumour samples are present in the discovery set.

336

337 HNSCC are the sixth leading cause of cancer worldwide with 5-year survival of less
 338 than 50% (Ferlay *et al*, 2010; Mishra & Meherotra, 2014). Recent high-throughput studies
 339 employing computational methods have identified various genetic, transcriptomic and
 340 epigenetic changes from different subsites of HNSCC from different geographies (Agrawal
 341 *et al*, 2011; Cancer Genome Atlas, 2015; India Project Team of the International Cancer
 342 Genome, 2013; Krishnan *et al*, 2015; Pickering *et al*, 2013). Early-stage patients with
 343 HNSCC are usually treated using a single modality like surgery or radiotherapy whereas
 344 advanced-stage patients benefit from multi-modality therapies (Ridge *et al*, 2016). In head
 345 and neck tumours, identifying patients with tumours *a priori* that may undergo distant
 346 metastasis or loco-regional recurrence using primary-tumour-derived molecular signature
 347 will help manage patients better. *CAFE MOCHA* was tested using a robust dataset of 434
 348 HNSCC tumours from TCGA where data on all four molecular events were available.
 349 Despite the MR44 being an integrated signature, drawn from 83 metastatic/recurrent
 350 tumours with four different somatic events (mut, cnv, expr and meth) and two coupled
 351 events (fmeth and fcncv) available on all the tumours, the discovery sensitivity did not attain
 352 close to 100% (sensitivity was 79.52%). This means that ~20% of the metastatic/recurrent
 353 tumours could not be classified using the integrated MR44 signature. This could indicate

354 two possibilities: first, there are other types of tumour-specific changes that need to be
 355 assayed and accounted for in order to derive a truly complete distant metastasis and
 356 recurrence-associated signature, and/or, second: the sample size of 83
 357 metastatic/recurrent tumours was not sufficient (the predictive power of discovery was not
 358 optimum). The fact that the validation sensitivity of MR44 was 100% in an independent
 359 cohort does not deter from either of these conclusions as the number of tumours in the
 360 validation set was small ($n = 18$).

361

362 About half of the genes in the MR44 signature have been reported previously to be
 363 associated with prognosis, survival, recurrence and distant metastasis for various cancer
 364 types. For example, *ITGA9* is reported as a tumour suppressor gene in non-small cell lung
 365 cancer (Pastuszak-Lewandoska *et al*, 2016) and is involved in cell migration and invasion
 366 in melanoma (Zhang *et al*, 2016). Additionally, epigenetic inactivation of *ITGA9* is linked
 367 with its expression in nasopharyngeal and breast cancer (Mostovich *et al*, 2011; Nawaz *et al*,
 368 2015). *NRAS* is linked with survival of patients with liver metastases in colorectal
 369 cancer (Vauthey *et al*, 2013) and acts as a prognostic factor in metastatic melanoma
 370 (Jakob *et al*, 2012). The chromosomal region containing *DVL2* gene frequently undergoes
 371 LOH in patients with colorectal tumours (Kurashina *et al*, 2008). *RPL26A1* expression was
 372 a prognostic marker in ER-positive breast tumours (Wang & Zhang, 2007) and liver
 373 metastases in colorectal cancer (Nakamura & Furukawa, 2003). *MORF4L1* was found to
 374 be one of the candidate genes with copy number reductions in breast cancer (Chen *et al*,
 375 2007). *FGFR4* profile was observed to be prognostically relevant in squamous cell
 376 carcinoma of the mouth and oropharynx (Dutra *et al*, 2012), esophagus (Shim *et al*, 2016),
 377 and gastric cancer (Murase *et al*, 2014). *ANXA11* expression is one of the prognostic
 378 markers in prostate cancer (Chandran *et al*, 2007; Tsai *et al*, 2013). *ZBTB7A* plays a role
 379 in suppressing tumour metastasis in gastric cancer (Shi *et al*, 2015). Loss of stromal *CAV1*

380 expression predicts poor survival in colorectal cancer (Zhao *et al*, 2015). *ARHGEF38*
381 expression significantly differed between high and low recurrence-free survival groups in
382 prostate cancer (Tandefelt *et al*, 2013). *OXCT1* was shown to act as an oncogene in
383 human breast cancer cells (Martinez-Outschoorn *et al*, 2012). *RICTOR* regulates cancer
384 cell metastases in breast cancer cell lines (Zhang *et al*, 2010). *RPAP2* associates with
385 breast cancer recurrence (Baker *et al*, 2014). miR573 inhibits prostate cancer metastases
386 (Wang *et al*, 2015). *AIMP1* is down regulated in gastric and colorectal cancer (Kim *et al*,
387 2014). *FAM134C* is a cancer-relapse marker in breast and ovarian cancer (Guo, 2011).
388 *LIMS1* (PINCH signalling) has been linked to distant metastasis in pancreatic stromal cells
389 (Scaife *et al*, 2010). *EGLN1* (commonly referred to as *PHD2*) is an oxygen sensor that
390 promotes breast cancer metastases (Kuchnio *et al*, 2015). *RPLP2* is one of the 10-gene
391 prognostic markers for gastric cancer (Zhang *et al*, 2011). *TOLLIP* was found to be
392 significantly and differentially expressed in colorectal metastatic cells (Barderas *et al*,
393 2013). *ZNF490* was found to be associated with breast cancer recurrence (Baker *et al*,
394 2013). MR44 contains genes implicated in MTOR, MAPK and PI3K-AKT signalling
395 pathways via *DVL2*, *FGF10*, *FGFR4*, *RICTOR*, *ITGA9*, *NRAS* and *CAV1* genes
396 (Supplementary Table S4).

397 Although the discovery module of *CAFE MOCHA* uses 450k methylation array and
398 RSEM-normalized RNASeq expression data, the predict module is not restricted to the
399 assays being performed on the same platform so long as the user provides data in the
400 same format for a matched normal. Future versions of *CAFE MOCHA* will incorporate
401 cross-platform converter wherein the user can deposit data generated with multiple
402 platforms and in multiple formats, thus making the tool truly platform agnostic. Additionally,
403 *CAFE MOCHA* has the ability to use an underlying tissue-specific normal database,
404 especially where expression and methylation data is not available, for un-matched normal
405 samples. However, if data for a matched normal is not available, the user must use the

same assays and formats, used in the discovery module to minimize assay/platform related errors.

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733

734 **Table 1:** Sample cohorts used in the discovery and validation modules of *CAFE MOCHA*

735 for discovering metastatic/recurrent signature MR44 in head and neck squamous cell

736 carcinoma (HNSCC).

737

Discovery			
Stage 1	Source	TCGA HNSCC (http://tinyurl.com/jhmg9b9), data available on all the 4 event types (mut, CNV, exp, meth) on tumor:matched normal samples.	
	Total Number of tumors	434	
	Metastatic/Recurrent	83	
	Tumors without metastasis/recurrence	351	
Stage 2	Source	Data on at least one event type available from the same matched tumor:normal sample.	
		TCGA HNSCC	OTSCC (Krishnan <i>et al</i> , 2015; Krishnan <i>et al</i> , 2016)
	Total number of tumors	42	37
	Metastatic/Recurrent	4	15
	Tumors without metastasis/recurrence	38	22
	Adjacent normal tissue	0	37
Validation			
	Source	OTSCC (Krishnan <i>et al</i> , 2015; Krishnan <i>et al</i> , 2016) (matched tumor:normal data on all event types from the same tumors)	
	Total number of tumors	18	
	Metastatic/Recurrent	3	
	Tumors without metastasis/recurrence	15	
	Adjacent normal tissue	18	

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743 **Figure Legends**

744 Figure 1: *CAFE MOCHA* application workflow and graphical-user-interface. A. Discovery,
745 and Prediction modules. B. Integrated analyses.

746

747 Figure 2: Complete specificity margin based clustering (CSMBC) algorithm for quantitative
748 and coupled events.

749 Clustering of quantitative and coupled events, for three clinical sub-categories i , j and k is
750 demonstrated here. Panel A: linking of quantitative events such as expression or
751 methylation to clinical sub-categories i , j and k (shades of blue). Boundaries are
752 determined in a supervised manner, as the minimum and maximum limits of the
753 quantitative ranges for each clinical sub-category. Overlaps are estimated as per the
754 equations illustrated in the figure. Samples whose expression or methylation values lie
755 outside the regions of overlap, 100% specific to a clinical sub-category are factored in
756 towards the sensitivity of that gene for that clinical sub-category. Panel B: clinical linking of
757 coupled events such as fmeth (shades of orange) resulting from a combination of two
758 quantitative events (expr – shades of blue and meth – shades of purple). The expression
759 event is mapped along the first dimension and the methylation event is mapped along the
760 second, and the samples, which observe both, expression and methylation, boundaries,
761 contribute to the sensitivity of that fmeth event for that clinical sub-category. Panel C:
762 clinical linking of coupled events such as fcnv (shades of dark orange) resulting from a
763 combination of one quantitative event (expression – shades of blue) and another
764 categorical event (CNV – shades of green). Here, the fcnv event linked to a clinical sub-
765 category is determined by both, expression boundaries for a clinical sub-group, and
766 presence of CNVs for the same samples in that clinical sub-group.

767

768 Figure 3: Discovery heatmap (A) and per-event validation sensitivity (B) of 44-gene
769 integrated signature (MR44) for distant metastasis and recurrence in the HNSCC
770 discovery set.

771 An integrated signature associated with metastasis/recurrence was derived from
772 combining six event types (mut: red, fmeth: dark orange, fcnv: orange, cnv: green, expr:
773 blue and meth: purple). Cumulative sample frequency (%) for individual event types is
774 represented as a histogram. The per-event validation sensitivity is represented as bubbles,
775 where the bubble size is proportional to the sample frequency of that event in the
776 validation cohort.

777

778 Figure 4: Comparison of detection sensitivities and total numbers of events required
779 achieving the sensitivity in one (A), two (B), three (C), four (D), five (E) and all six (F) event
780 types. Utilizing all the six events (F) shows the power of integration both on sensitivity of
781 detection (black dot) and the number of events (colored bars for all the six individual event
782 types) required to attain the sensitivity.

783

784 **Supplementary Data Legend**

785 Supplementary Table S1: TCGA HNSCC tumor samples ($n = 434$) and clinical attributes
786 used for the discovery of MR44.

787

788 Supplementary Table S2: Oral tongue squamous cell carcinoma (OTSCC) and TCGA
789 HNSCC samples lacking cross-platform overlap, and their clinical attributes used for
790 confirmation of MR44 discovery.

791

792 Supplementary Table S3: Oral tongue squamous cell carcinoma (OTSCC) ($n = 18$) with all

793 four events assayed within the same tumor, and their clinical attributes used for the
794 validation.

795 Supplementary Table S4: Discovered events associated with Metastases and Recurrence
796 in HNSCC, pathways mapped, confirmation and validation status.

797

798 Supplementary Figure S1: Events associated with distant metastasis and recurrence in
799 HNSCC with single-event or multi-event signatures, selected in individual event type (mut:
800 red, fmeth: d orange, fcnv: orange, cnv: green, expr: blue and meth: purple) and various
801 integrated analyses, combining different numbers of event types.

802

A

B

Supplementary Table S1: TCGA HNSCC samples and clinical attributes used for discovery.

SampleID	R (Loco-regional recurrence); M1(metastasis); M0 (Non-metastatic/Non-recurrent) tumors; N (Solid Tissue Normals).
TCGA-BA-4074-01	R
TCGA-BA-4075-01	R
TCGA-BA-4076-01	R
TCGA-BA-4077-01	M0
TCGA-BA-4078-01	M0
TCGA-BA-5149-01	M0
TCGA-BA-5151-01	M0
TCGA-BA-5152-01	M0
TCGA-BA-5153-01	R
TCGA-BA-5555-01	M0
TCGA-BA-5556-01	M0
TCGA-BA-5557-01	M0
TCGA-BA-5558-01	M0
TCGA-BA-5559-01	R
TCGA-BA-6868-01	M0
TCGA-BA-6869-01	M0
TCGA-BA-6870-01	M1
TCGA-BA-6871-01	M0
TCGA-BA-6872-01	M0
TCGA-BA-6873-01	M0
TCGA-BA-7269-01	M0
TCGA-BA-A4IF-01	R
TCGA-BA-A4IH-01	M0

TCGA-BA-A4II-01	R
TCGA-BA-A6D8-01	R
TCGA-BA-A6DA-01	M0
TCGA-BA-A6DB-01	M0
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TCGA-BA-A6DI-01	M0
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TCGA-BA-A6DL-01	M0
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TCGA-CN-5365-01	M1
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TCGA-CN-5369-01	M0
TCGA-CN-5370-01	R
TCGA-CN-5373-01	M0

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TCGA-CN-A642-01	M0
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TCGA-CQ-5323-01	M0

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TCGA-CQ-7071-01	M0
TCGA-CQ-7072-01	M0
TCGA-CQ-A4C6-01	M0

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TCGA-CQ-A4CD-01	M0
TCGA-CQ-A4CE-01	M0
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TCGA-CR-7386-01	R
TCGA-CR-7388-01	R
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TCGA-CR-7393-01	M0
TCGA-CR-7394-01	M0
TCGA-CR-7395-01	M0

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TCGA-CR-7398-01	M0
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TCGA-CR-7401-01	M0
TCGA-CR-7402-01	M0
TCGA-CR-7404-01	R
TCGA-CV-5430-01	R
TCGA-CV-5432-01	M0
TCGA-CV-5434-01	R
TCGA-CV-5435-01	R
TCGA-CV-5436-01	M0
TCGA-CV-5439-01	R
TCGA-CV-5440-01	M0
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TCGA-CV-7437-01	M0
TCGA-CV-7438-01	M0
TCGA-CV-7440-01	M0

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TCGA-CV-A45T-01	M0
TCGA-CV-A45U-01	M0
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TCGA-CV-A45Z-01	M0
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TCGA-CV-A6JO-01	M0
TCGA-CV-A6JT-01	M0
TCGA-CV-A6JU-01	M0
TCGA-CV-A6JY-01	M0
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TCGA-D6-A74Q-01	M0
TCGA-DQ-5624-01	M0
TCGA-DQ-5625-01	R

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TCGA-F7-A50G-01	M0
TCGA-F7-A50I-01	M0
TCGA-F7-A50J-01	M0
TCGA-F7-A61S-01	R
TCGA-H7-7774-01	R
TCGA-H7-8501-01	M0
TCGA-H7-A6C4-01	M0
TCGA-HD-7229-01	M0
TCGA-HD-7753-01	M0
TCGA-HD-7754-01	M0
TCGA-HD-7831-01	M0
TCGA-HD-7832-01	M0
TCGA-HD-7917-01	M0

TCGA-HD-8224-01	R
TCGA-HD-8314-01	M0
TCGA-HD-A633-01	R
TCGA-HL-7533-01	M0
TCGA-IQ-7630-01	M0
TCGA-IQ-7631-01	M0
TCGA-IQ-7632-01	M0
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TCGA-IQ-A61J-01	M0
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TCGA-KU-A66T-01	R
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TCGA-MT-A51X-01	M0
TCGA-MT-A67D-01	M0
TCGA-MT-A7BN-01	R
TCGA-MZ-A5BI-01	M0
TCGA-MZ-A6I9-01	R
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TCGA-P3-A6T5-01	R
TCGA-P3-A6T6-01	R
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TCGA-QK-A6IG-01	R
TCGA-QK-A6IH-01	R
TCGA-QK-A6II-01	R

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TCGA-QK-A6V9-01	M0
TCGA-QK-A6VB-01	M0
TCGA-QK-A6VC-01	M0
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TCGA-RS-A6TP-01	M0
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TCGA-T2-A6WZ-01	R
TCGA-T2-A6X0-01	M0
TCGA-T2-A6X2-01	M0
TCGA-TN-A7HI-01	M0
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TCGA-UF-A7JH-01	M0
TCGA-UF-A7JJ-01	M0
TCGA-UF-A7JK-01	M0

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TCGA-UF-A7JV-01	M0
TCGA-WA-A7GZ-01	M0
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TCGA-CV-5432-11	N
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TCGA-CV-5435-11	N
TCGA-CV-5436-11	N
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TCGA-CV-6003-11	N

TCGA-CV-6433-11	N
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TCGA-CV-6441-11	N
TCGA-CV-6933-11	N
TCGA-CV-6934-11	N
TCGA-CV-6935-11	N
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TCGA-CV-7416-11	N
TCGA-CV-7423-11	N
TCGA-CV-7424-11	N
TCGA-CV-7425-11	N
TCGA-CV-7432-11	N
TCGA-CV-7434-11	N
TCGA-CV-7437-11	N
TCGA-CV-7438-11	N
TCGA-CV-7440-11	N
TCGA-H7-A6C5-11	N
TCGA-HD-8635-11	N
TCGA-HD-A6HZ-11	N
TCGA-HD-A6I0-11	N
TCGA-WA-A7GZ-11	N

Supplementary Table S2: Oral tongue squamous cell carcinoma (OTSCC) and TCGA HNSC samples lacking cross-platform overlap, and their clinical attributes used for validation.

SampleID	R (Loco-regional recurrence); M1(metastasis); M0 (Non-metastatic/Non-recurrent) tumors; N (Solid Tissue Normals)
OT10_T	M0
OT13_T	M0
OT15_T	R
OT16_T	R
OT18_T	M1
OT20_T	R
OT21_T	R
OT23_T	M0
OT25_T	M0
OT27_T	M0
OT29_T	M0
OT30_T	M0
OT31_T	M0
OT32_T	M0
OT33_T	M0
OT34_T	R
OT35_T	M0
OT36_T	R
OT37_T	M0
OT38_T	R
OT39_T	M0
OT4_T	R

OT40_T	R
OT41_T	M0
OT42_T	M0
OT43_T	M0
OT45_T	M0
OT46_T	M0
OT47_T	M0
OT48_T	R
OT49_T	R
OT5_T	R
OT50_T	M1
OT53_T	M0
OT55_T	R
OT7_T	M0
OT9_T	M0
TCGA-BA-A6DE-01	M0
TCGA-BA-A6DF-01	M0
TCGA-BA-A6DF-01	M0
TCGA-BA-A6DL-01	M0
TCGA-BA-A8YP-01	M0
TCGA-BA-A8YP-01	M0
TCGA-BB-7864-01	M0
TCGA-BB-7866-01	M0
TCGA-BB-7866-01	M0
TCGA-C9-A480-01	M0
TCGA-CN-4722-01	M0
TCGA-CN-4722-01	M0

TCGA-CN-4734-01	M0
TCGA-CN-4734-01	M0
TCGA-CN-5361-01	M0
TCGA-CN-5361-01	M0
TCGA-CQ-6219-01	R
TCGA-CQ-6219-01	R
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TCGA-CV-7446-01	M0
TCGA-CV-7568-01	M0
TCGA-CV-7568-01	M0

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TCGA-F7-8298-01	M0
TCGA-F7-8298-01	M0
TCGA-H7-8501-01	M0
TCGA-H7-8502-01	M0
TCGA-H7-8502-01	M0
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TCGA-H7-A6C5-01	M0
TCGA-H7-A6C5-01	M0
TCGA-IQ-A61J-01	M0
TCGA-IQ-A61K-01	M0
TCGA-IQ-A61K-01	M0
TCGA-IQ-A61L-01	M0
TCGA-IQ-A61L-01	M0
TCGA-KU-A6H7-06	M0
TCGA-KU-A6H7-06	M0
TCGA-QK-A6VC-01	M0
TCGA-QK-A8Z7-01	M0
TCGA-QK-A8Z7-01	M1
TCGA-QK-A8Z8-01	M1
TCGA-QK-A8Z8-01	R
TCGA-QK-A8Z9-01	R
TCGA-QK-A8Z9-01	R
TCGA-QK-A8ZA-01	M0
TCGA-QK-A8ZB-0	M0
TCGA-QK-A8ZB-01	M0
TCGA-QK-AA3J-01	M0

TCGA-QK-AA3J-01	M0
TCGA-UF-A71A-06	M0
TCGA-UF-A71A-06	M0
OT10_N	N
OT13_N	N
OT15_N	N
OT16_N	N
OT18_N	N
OT20_N	N
OT21_N	N
OT23_N	N
OT25_N	N
OT27_N	N
OT29_N	N
OT30_N	N
OT31_N	N
OT32_N	N
OT33_N	N
OT34_N	N
OT35_N	N
OT36_N	N
OT37_N	N
OT38_N	N
OT39_N	N
OT4_N	N
OT40_N	N
OT41_N	N

OT42_N	N
OT43_N	N
OT45_N	N
OT46_N	N
OT47_N	N
OT48_N	N
OT49_N	N
OT5_N	N
OT50_N	N
OT53_N	N
OT55_N	N
OT7_N	N
OT9_N	N

Supplementary Table S3: Oral tongue squamous cell carcinoma (OTSCC) with all four events assayed within the same tumor, and their clinical attributes used for validation.	
S a m p l e I D	R (Loco-regional recurrence); M1(metastasis); M0 (Non-metastatic/Non-recurrent) tumors; N (Solid Tissue Normals).
OT1_T	M0
OT11_T	M0
OT12_T	M0
OT14_T	M0

OT17_T	M0
OT19_T	M0
OT2_T	M1
OT22_T	M0
OT24_T	M0
OT26_T	M0
OT28_T	M0
OT52_T	M0
OT54_T	M0
OT3_T	M0
OT6_T	M0
OT8_T	M0
OT44_T	R
OT51_T	M1
OT1_N	N
OT11_N	N
OT12_N	N
OT14_N	N
OT17_N	N
OT19_N	N
OT2_N	N
OT22_N	N
OT24_N	N
OT26_N	N
OT28_N	N
OT52_N	N

OT54_N	N
OT3_N	N
OT6_N	N
OT8_N	N
OT44_N	N
OT51_N	N

Supplementary Table S4: Discovered events associated with Metastases and Recurrence in TCGA HNSCC, pathways mapped, confirmation and validation status.

user_selected_clinical_variable	event_affected_gene	event_type	event	sample_frequency	event_priority	filter_type	cancer_pathways	confirmation	validation	minimal_discovery_panel
Met/REC	ACSS3	cnv	D_ACSS3	1.20482	D	event_priority_filter	NA	YES	YES	YES
Met/REC	AGO3	cnv	D_AGO3	1.20482	D	event_priority_filter	NA	YES	YES	YES
Met/REC	ANAPC4	cnv	D_ANAPC4	1.20482	D	event_priority_filter	cell_cycle	YES	YES	NO
Met/REC	ANKFY1	fcnv	D_ANKFY1	2.40964	B	event_priority_filter	NA	YES	YES	NO
Met/REC	ANO5	cnv	I_ANO5	2.40964	D	event_priority_filter	NA	YES	YES	NO
Met/REC	ANXA11	fcnv	I_ANXA11	1.20482	B	event_priority_filter	NA	YES	YES	YES
Met/REC	ARHGAP10	cnv	I_ARHGAP10	1.20482	D	event_priority_filter	NA	YES	YES	NO
Met/REC	ARHGEF38	cnv	D_ARHGEF38	1.20482	D	event_priority_filter	NA	YES	YES	YES
Met/REC	CALY	cnv	D_CALY	1.20482	D	event_priority_filter	NA	YES	YES	NO
Met/REC	CCDC97	fcnv	I_CCDC97	1.20482	B	event_priority_filter	NA	YES	YES	NO
Met/REC	CCKAR	cnv	D_CCKAR	1.20482	D	event_priority_filter	NA	YES	YES	NO
Met/REC	CCPG1	fcnv	I_CCPG1	1.20482	B	event_priority_filter	NA	YES	YES	NO
Met/REC	CIC	fcnv	I_CIC	1.20482	B	event_priority_filter	NA	YES	YES	NO
Met/REC	CNDP1	cnv	I_CNDP1	2.40964	D	event_priority_filter	NA	YES	YES	NO
Met/REC	CNKS3	cnv	D_CNKS3	2.40964	D	event_priority_filter	NA	YES	YES	NO

Met/REC	COPS2	fcnv	I_COPS2	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	CSRP3	cnv	I_CSRP3	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	DBX1	cnv	I_DBX1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	DCLK2	cnv	I_DCLK2	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	DOCK2	cnv	D_DOCK2	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	DVL2	fcnv	D_DVL2	1.20482	B	event_priority_ filter	mtor_wnt	YES	YES	YES
Met/REC	ECHS1	cnv	D_ECHS1	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ERF	fcnv	I_ERF	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	FBXW7	cnv	I_FBXW7	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	FGF10	cnv	D_FGF10	1.20482	D	event_priority_ filter	mapk_pi3k _akt	YES	YES	YES
Met/REC	FGFR4	fcnv	I_FGFR4	1.20482	B	event_priority_ filter	mapk_pi3k _akt	YES	YES	YES
Met/REC	FRMPD4	cnv	I_FRMPD4	2.40964	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	FUOM	cnv	D_FUOM	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GAS2	cnv	I_GAS2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GBE1	cnv	I_GBE1	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GCSAML	cnv	D_GCSAML	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GNPDA2	cnv	D_GNPDA2	3.61446	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GRXCR1	cnv	D_GRXCR1	3.61446	D	event_priority_ filter	NA	YES	YES	NO

Met/REC	GTF2H1	cnv	I_GTF2H1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	GUF1	cnv	D_GUF1	3.61446	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	HK2	cnv	D_HK2	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	HTATIP2	cnv	I_HTATIP2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	IGSF22	cnv	I_IGSF22	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	KCNC1	cnv	I_KCNC1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	LDHAL6A	cnv	I_LDHAL6A	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	MAGI3	cnv	I_MAGI3	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	MAT1A	fcnv	I_MAT1A	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	MIR573	cnv	I_MIR573	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	MMAA	cnv	I_MMAA	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	MORC3	fcnv	I_MORC3	1.20482	B	event_priority_ filter	NA	NO	NA	NO
Met/REC	MORF4L1	fcnv	D_MORF4L1	1.20482	B	event_priority_ filter	NA	YES	YES	YES
Met/REC	MPHOSPH 6	cnv	D_MPHOSPH6	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	MRGPRX2	cnv	I_MRGPRX2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	MTHFS	fcnv	D_MTHFS	1.20482	B	event_priority_ filter	NA	YES	YES	YES
Met/REC	MUC15	cnv	I_MUC15	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	MYO5C	fcnv	I_MYO5C	1.20482	B	event_priority_ filter	NA	YES	YES	NO

Met/REC	NAV2	cnv	I_NAV2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	NEDD4	fcnv	I_NEDD4	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	NELL1	cnv	I_NELL1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	NLRP3	cnv	D_NLRP3	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	NNT	cnv	D_NNT	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	NR3C2	cnv	I_NR3C2	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	NSUN5	fcnv	D_NSUN5	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	OR2B11	cnv	D_OR2B11	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	OR2C3	cnv	D_OR2C3	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	OXCT1	cnv	D_OXCT1	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	PFKM	fcnv	D_PFKM	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	PLAUR	fcnv	I_PLAUR	1.20482	B	event_priority_ filter	NA	YES	YES	YES
Met/REC	PRAP1	cnv	D_PRAP1	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	PRMT3	cnv	I_PRMT3	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	PTPN5	cnv	I_PTPN5	2.40964	D	event_priority_ filter	mapk	YES	YES	NO
Met/REC	PTPRR	cnv	D_PTPRR	1.20482	D	event_priority_ filter	mapk	NO	NA	NO
Met/REC	RAB27A	fcnv	I_RAB27A	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	RERGL	cnv	D_RERGL	1.20482	D	event_priority_ filter	NA	YES	YES	YES

Met/REC	RFC2	fcnv	D_RFC2	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	RICTOR	cnv	D_RICTOR	1.20482	D	event_priority_ filter	mtor	YES	YES	YES
Met/REC	RPAP2	cnv	D_RPAP2	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	RPL26L1	fcnv	I_RPL26L1	1.20482	B	event_priority_ filter	NA	YES	YES	YES
Met/REC	RPS3A	cnv	I_RPS3A	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SAA4	cnv	I_SAA4	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SAAL1	cnv	I_SAAL1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SEL1L3	cnv	D_SEL1L3	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SENP1	fcnv	D_SENP1	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	SERGEF	cnv	I_SERGEF	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SH3D19	cnv	I_SH3D19	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SLC17A6	cnv	I_SLC17A6	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SLC34A2	cnv	D_SLC34A2	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SLC5A12	cnv	I_SLC5A12	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SMAD1	cnv	I_SMAD1	1.20482	D	event_priority_ filter	tgf	YES	YES	NO
Met/REC	SMIM20	cnv	D_SMIM20	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SMIM21	cnv	I_SMIM21	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SPTY2D1	cnv	I_SPTY2D1	2.40964	D	event_priority_ filter	NA	YES	YES	NO

Met/REC	SRBD1	cnv	D_SRBD1	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SSBP2	cnv	D_SSBP2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SVIP	cnv	I_SVIP	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	SYDE2	cnv	D_SYDE2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TBC1D19	cnv	D_TBC1D19	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TMEM154	cnv	I_TMEM154	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TMEM155	fcnv	I_TMEM155	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	TMEM86A	cnv	I_TMEM86A	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TPH1	cnv	I_TPH1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TSG101	cnv	I_TSG101	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	TSHZ1	cnv	I_TSHZ1	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	UEVLD	cnv	I_UEVLD	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	USP32	cnv	D_USP32	1.20482	D	event_priority_ filter	NA	YES	YES	YES
Met/REC	USP8	fcnv	I_USP8	1.20482	B	event_priority_ filter	NA	YES	YES	NO
Met/REC	YIPF7	cnv	D_YIPF7	3.61446	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ZADH2	cnv	I_ZADH2	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ZBTB7A	fcnv	I_ZBTB7A	1.20482	B	event_priority_ filter	NA	YES	YES	YES
Met/REC	ZCCHC4	cnv	D_ZCCHC4	1.20482	D	event_priority_ filter	NA	YES	YES	NO

Met/REC	ZDHHC13	cnv	I_ZDHHC13	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ZNF407	cnv	I_ZNF407	2.40964	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ZNF511	cnv	D_ZNF511	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ZNF827	cnv	I_ZNF827	1.20482	D	event_priority_ filter	NA	YES	YES	NO
Met/REC	ACAD8	mut	ACAD8	3.61446	A	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	AIMP1	expr	AIMP1	7.22892	NA	event_priority_ filter	NA	YES	YES	YES
Met/REC	C1QA	expr	C1QA	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	C1QB	expr	C1QB	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	CHPF2	expr	CHPF2	6.0241	E	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	CHPF2	expr	CHPF2	6.0241	NA	event_priority_ filter	NA	NO	NA	NO
Met/REC	CIC	expr	CIC	7.22892	E	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	CIC	expr	CIC	7.22892	NA	event_priority_ filter	NA	YES	YES	YES
Met/REC	CTU1	expr	CTU1	4.81928	E	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	CTU1	expr	CTU1	4.81928	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	DOHH	expr	DOHH	7.22892	NA	event_priority_ filter	NA	YES	YES	YES
Met/REC	DQX1	expr	DQX1	4.81928	E	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	DQX1	expr	DQX1	4.81928	NA	event_priority_ filter	NA	NO	NA	NO
Met/REC	ECE2	expr	ECE2	6.0241	E	sample_freque ncy_filter	NA	NO	NA	NO

Met/REC	ECE2	expr	ECE2	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	EEF1B2	mut	EEF1B2	1.20482	A	event_priority_ filter	NA	YES	YES	NO
Met/REC	FAM102A	expr	FAM102A	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	FAM102A	expr	FAM102A	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	FAM134C	expr	FAM134C	6.0241	E	event_priority_ filter	NA	YES	YES	YES
Met/REC	FAM134C	expr	FAM134C	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	FOXO4	expr	FOXO4	6.0241	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	GMFB	expr	GMFB	6.0241	E	event_priority_ filter	NA	YES	YES	YES
Met/REC	GTF2IRD1	expr	GTF2IRD1	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	ITGA9	mut	ITGA9	1.20482	A	ecm_focal_ adhesion_p i3k_akt	YES	YES	YES	YES
Met/REC	KLF4	mut	KLF4	1.20482	A	event_priority_ filter	NA	YES	YES	NO
Met/REC	KLHDC7B	expr	KLHDC7B	6.0241	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	KLHDC7B	expr	KLHDC7B	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	LIMS1	expr	LIMS1	6.0241	E	event_priority_ filter	NA	YES	YES	YES
Met/REC	LIMS1	expr	LIMS1	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	MORC2	expr	MORC2	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	MORC2	expr	MORC2	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO

Met/REC	MRS2	expr	MRS2	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	NPM3	expr	NPM3	7.22892	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	NPM3	expr	NPM3	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	NRAS	mut	NRAS	1.20482	A	event_priority_ filter	apoptosis_ mapk_mtor _pi3k_akt_ vegf	YES	YES	YES
Met/REC	PCBP1	mut	PCBP1	2.40964	A	event_priority_ filter	NA	YES	YES	NO
Met/REC	PGS1	expr	PGS1	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	PGS1	expr	PGS1	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	PJA2	expr	PJA2	8.43373	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	PJA2	expr	PJA2	8.43373	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	PKP4	expr	PKP4	7.22892	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	PKP4	expr	PKP4	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	PPIAL4C	expr	PPIAL4C	7.22892	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	PPIC	expr	PPIC	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	REXO2	expr	REXO2	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	RNF139	expr	RNF139	7.22892	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	RNF139	expr	RNF139	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	SFRP1	expr	SFRP1	4.81928	NA	sample_freque ncy_filter	wnt	NO	NA	NO

Met/REC	SIGLEC1	expr	SIGLEC1	3.61446	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	SLC9A5	expr	SLC9A5	4.81928	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	SLC9A5	expr	SLC9A5	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	TFDP1	mut	TFDP1	2.40964	A	event_priority_ filter	cell_cycle_t gf	NO	NA	NO
Met/REC	ZBP1	expr	ZBP1	3.61446	E	event_priority_ filter	NA	NO	NA	NO
Met/REC	ACAT2	meth	ACAT2_cg2350 0094	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	AGAP1	meth	AGAP1_cg0880 5497	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ALDOA	fmeth	ALDOA_ALDOA _cg07025134	2.40964	C	event_priority_ filter	NA	NO	NA	NO
Met/REC	AMH	meth	AMH_cg266598 05	7.22892	NA	sample_freque ncy_filter	camp_cyto kine_tgf	NO	NA	NO
Met/REC	ASPSCR1	meth	ASPSCR1_cg06 238300	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	BLNK	fmeth	BLNK_BLNK_cg 02980499	1.20482	C	event_priority_ filter	NA	NO	NA	NO
Met/REC	BRMS1	meth	BRMS1_cg2158 2163	7.22892	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	CAV1	fmeth	CAV1_MIR107_ cg24445034	1.20482	C	event_priority_ filter	focal_adhe sion	YES	YES	YES
Met/REC	CCDC59	fmeth	CCDC59_CCD C59_cg0190390 3	1.20482	C	event_priority_ filter	NA	YES	YES	NO
Met/REC	CCND2	meth	CCND2_cg0380 1902	6.0241	NA	sample_freque ncy_filter	cell_cycle_f ocal_adhes ion_jak_sta t_p53_pi3k _akt_wnt	NO	NA	NO
Met/REC	CHAF1A	meth	CHAF1A_cg238 11775	9.63855	NA	sample_freque ncy_filter	NA	NO	NA	NO

Met/REC	CHST12	meth	CHST12_cg10145585	6.0241	NA	sample_freque				
			CRABP2_cg27493997	6.0241	NA	ncy_filter	NA	NO	NA	NO
Met/REC	CRABP2	meth				sample_freque				
			CROCC_CROC			ncy_filter	NA	NO	NA	NO
Met/REC	CROCC	fmeth	C_cg23732962	1.20482	C	event_priority_				
			CYBA_CYBA_c			filter	NA	NO	NA	NO
Met/REC	CYBA	fmeth	g24046411	1.20482	C	event_priority_				
			CYBA_CYBA_c			filter	NA	NO	NA	NO
Met/REC	CYBA	fmeth	g27176614	1.20482	C	event_priority_				
			DCAF12L1_cg01913196	4.81928	NA	filter	NA	NO	NA	NO
Met/REC	DCAF12L1	meth				sample_freque				
			DLG2_cg10901805	7.22892	NA	ncy_filter	NA	NO	NA	NO
Met/REC	DLG2	meth				sample_freque				
			DPP9_cg24423897	7.22892	NA	ncy_filter	NA	NO	NA	NO
Met/REC	DPP9	meth				sample_freque				
			DPYSL2_cg02835343	7.22892	NA	ncy_filter	NA	NO	NA	NO
Met/REC	DPYSL2	meth				sample_freque				
			EGLN1_cg20015535	7.22892	NA	ncy_filter	NA	YES	YES	YES
Met/REC	EGLN1	meth				sample_freque				
			EIF5A_cg24699433	7.22892	NA	ncy_filter	NA	NO	NA	NO
Met/REC	EIF5A	meth				event_priority_				
			EIF5A2 EIF5A2_cg12598803	1.20482	C	filter	NA	NO	NA	NO
Met/REC	EIF5A2	fmeth				event_priority_				
			EIF5A2 EIF5A2_cg26209058	1.20482	C	filter	NA	NO	NA	NO
Met/REC	EIF5A2	fmeth				sample_freque				
			EN1_cg02739346	4.81928	NA	ncy_filter	NA	NO	NA	NO
Met/REC	EN1	meth								
			EP400NL_EP400NL_cg25632983	1.20482	C	event_priority_				
Met/REC	EP400NL	fmeth				filter	NA	NO	NA	NO
			ERBB2_MIR125A_cg19782652	1.20482	C	adherens_f				
Met/REC	ERBB2	fmeth				ocal_adhes				
			ERBB2_MIR134_cg26238975	1.20482	C	ion	YES	YES	YES	NO
Met/REC	ERBB2	fmeth				adherens_f				
						ocal_adhes	NO	NA	NO	NO

							ion			
Met/REC	FBLN5	meth	FBLN5_cg21883802	7.22892	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	FBN1	meth	FBN1_cg12975862	4.81928	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	FBXO43	meth	FBXO43_cg23700125	9.63855	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	FNTA	fmeth	FNTA_FNTA_cg07294234	2.40964	C	event_priority_				
						filter	NA	YES	YES	YES
Met/REC	GALNT2	meth	GALNT2_cg00589617	6.0241	F	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	GALNT2	meth	GALNT2_cg00589617	6.0241	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	GDAP1	fmeth	GDAP1_GDAP1_cg22105613	2.40964	C	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	GLRX5	meth	GLRX5_cg26007049	7.22892	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	GNB4	fmeth	GNB4_GNB4_cg01750654	1.20482	C	event_priority_				
						filter	pi3k_akt	NO	NA	NO
Met/REC	HAUS5	fmeth	HAUS5_HAUS5_cg05296832	1.20482	C	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	HEATR1	meth	HEATR1_cg00907549	7.22892	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	HNRNPM	fmeth	HNRNPM_HNRNPM_cg05923062	1.20482	C	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	HOMER3	fmeth	HOMER3_HOMER3_cg19788957	1.20482	C	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	HTR3E	fmeth	HTR3E_HTR3E_cg11158819	1.20482	C	event_priority_				
						filter	NA	NO	NA	NO
Met/REC	KLHL20	meth	KLHL20_cg11720170	7.22892	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO
Met/REC	LBH	meth	LBH_cg25072436	7.22892	NA	sample_freque				
						ncy_filter	NA	NO	NA	NO

Met/REC	LMX1A	fmeth	LMX1A_LMX1A_cg23971170	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	LRRK1	meth	LRRK1_cg24163563	6.0241	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	MAGEA10	fmeth	MAGEA10_MAGEA10_cg19964192	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	MAN2B1	meth	MAN2B1_cg02484047	8.43373	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	MAPK12	meth	MAPK12_cg21974239	8.43373	NA	sample_frequency_filter	mapk vegf	NO	NA	NO
Met/REC	MBP	meth	MBP_cg00989538	6.0241	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	MED11	meth	MED11_cg09832947	8.43373	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	MORF4L1	fmeth	MORF4L1_MORF4L1_cg20905746	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	NLGN2	meth	NLGN2_cg10092265	7.22892	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	NOS3	meth	NOS3_cg12547085	7.22892	NA	sample_frequency_filter	pi3k akt vegf	NO	NA	NO
Met/REC	NR1H2	meth	NR1H2_cg14673743	4.81928	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	PCCB	meth	PCCB_cg05582311	7.22892	NA	sample_frequency_filter	NA	YES	YES	YES
Met/REC	PCNT	fmeth	PCNT_PCNT_cg13822122	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	PNMT	fmeth	PNMT_PNMT_cg16268778	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	PPP1R1B	fmeth	PPP1R1B_PPP1R1B_cg06068801	1.20482	C	event_priority_filter	camp	NO	NA	NO
Met/REC	PPP1R1B	fmeth	PPP1R1B_PPP1R1B_cg09762778	1.20482	C	event_priority_filter	camp	NO	NA	NO

Met/REC	PRF1	fmeth	PRF1_PRF1_cg12336290	1.20482	C	event_priority_filter	apoptosis	NO	NA	NO
Met/REC	RBMS2	meth	RBMS2_cg23002907	8.43373	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	RNF138	meth	RNF138_cg22141237	4.81928	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	RPLP2	meth	RPLP2_cg01485797	6.0241	NA	sample_frequency_filter	NA	YES	YES	YES
Met/REC	RPRD1A	fmeth	RPRD1A_RPRD1A_cg00019809	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	RPRD1A	fmeth	RPRD1A_RPRD1A_cg19629710	1.20482	C	event_priority_filter	NA	YES	YES	NO
Met/REC	RYBP	meth	RYBP_cg04421631	7.22892	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	SLC45A4	meth	SLC45A4_cg08829393	7.22892	NA	sample_frequency_filter	NA	YES	YES	YES
Met/REC	SNUPN	meth	SNUPN_cg22258732	4.81928	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	SORBS3	meth	SORBS3_cg07924703	6.0241	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	SPIRE2	meth	SPIRE2_cg07402062	8.43373	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	SPOPL	fmeth	SPOPL_SPOPL_cg09464263	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	STIM1	meth	STIM1_cg04346968	6.0241	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	TAF1D	fmeth	TAF1D_TAF1D_cg10353388	1.20482	C	event_priority_filter	NA	NO	NA	NO
Met/REC	TEX11	meth	TEX11_cg08167097	7.22892	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	TNK2	meth	TNK2_cg03207310	4.81928	NA	sample_frequency_filter	NA	NO	NA	NO
Met/REC	TNPO1	meth	TNPO1_cg05579703	6.0241	NA	sample_frequency_filter	NA	NO	NA	NO

Met/REC	TOLLIP	meth	TOLLIP_cg0136 9233	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	TRRAP	meth	TRRAP_cg0345 7229	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	UMPS	meth	UMPS_cg15050 328	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	UST	meth	UST_cg212730 29	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	WDR66	meth	WDR66_cg0176 5077	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ZFH3	meth	ZFH3_cg0570 4496	6.0241	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ZIC3	fmeth	ZIC3_ZIC3_cg1 0451760	1.20482	C	event_priority_ filter	NA	NO	NA	NO
Met/REC	ZNF121	meth	ZNF121_cg069 98238	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	ZNF410	fmeth	ZNF410_ZNF41 0_cg12152256	1.20482	C	event_priority_ filter	NA	NO	NA	NO
Met/REC	ZNF490	meth	ZNF490_cg240 93429	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES
Met/REC	ZNF497	fmeth	ZNF497_ZNF49 7_cg14989522	1.20482	C	event_priority_ filter	NA	NO	NA	NO
Met/REC	ZNF516	meth	ZNF516_cg162 75118	9.63855	F	event_priority_ filter	NA	NO	NA	NO
Met/REC	ZNF516	meth	ZNF516_cg162 75118	9.63855	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ZNF580	meth	ZNF580_cg262 09676	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ZNF581	meth	ZNF581_cg262 09676	4.81928	NA	sample_freque ncy_filter	NA	NO	NA	NO
Met/REC	ZNF791	meth	ZNF791_cg240 93429	6.0241	NA	sample_freque ncy_filter	NA	YES	YES	YES