RNA-seq Analysis with Tuxedo Tools

The RNA-seq pipeline "Tuxedo" consists of the TopHat spliced read mapper, that internally uses Bowtie or Bowtie 2 short read aligners, and several Cufflin ks tools that allows one to assemble transcripts, estimate their abundances, and tests for differential expression and regulation in RNA-seq samples.

Environment Requirements

The pipeline is currently available on Linux and macOS systems only.



If you haven't used the workflow samples in UGENE before, look at the "How to Use Sample Workflows" section of the documentation.

Workflow Sample Location

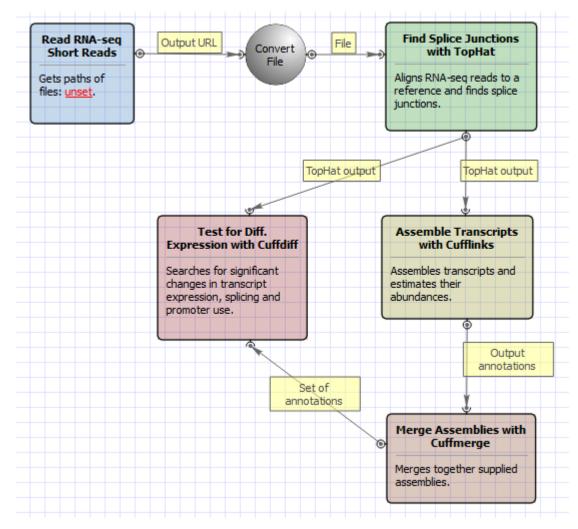
The workflow sample "RNA-seq Analysis with Tuxedo Tools" can be found in the "NGS" section of the Workflow Designer samples.

Workflow Image

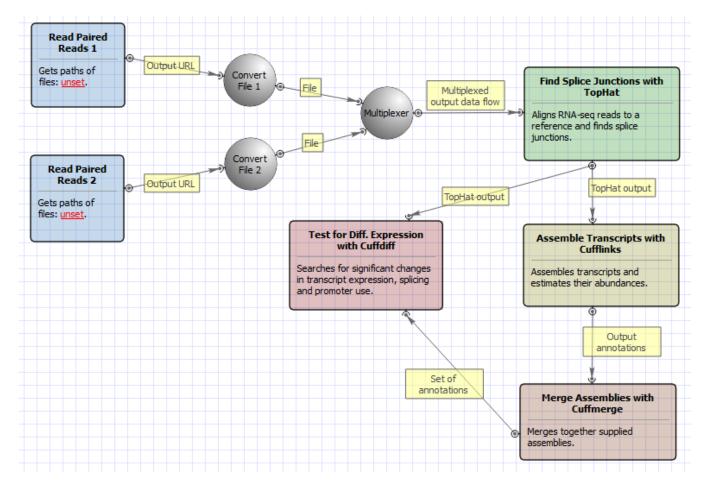
There are two short reads types of workflow: single-end and paired-end reads. For both of them there are three analysis types:

- 1. Full Tuxedo Pipeline use this pipeline to analyze multiple samples with TopHat, Cufflinks, Cuffmerge and Cuffdiff tools.
- 2. Single-sample Tuxedo Pipeline use this pipeline to analyze a single sample with TopHat and Cufflinks tools.
- 3. No-new-transcripts Tuxedo Pipeline use this pipeline to analyze multiple samples with TopHat and Cuffdiff tools only, i.e. without producing new transcripts.

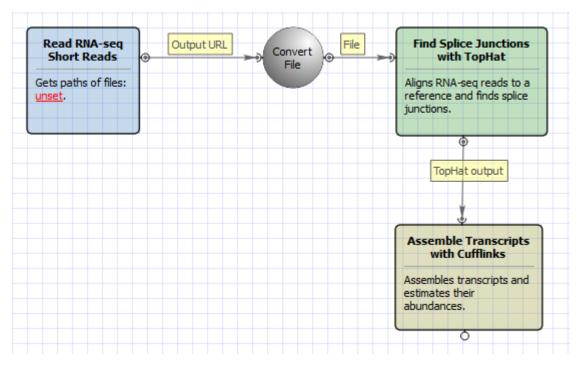
For Full Tuxedo Pipeline analysis type and single-end reads type the following workflow appears:



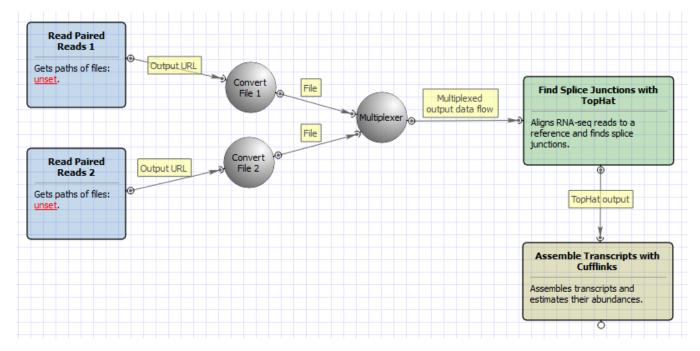
For Full Tuxedo Pipeline analysis type and paired-end reads type the following workflow appears:



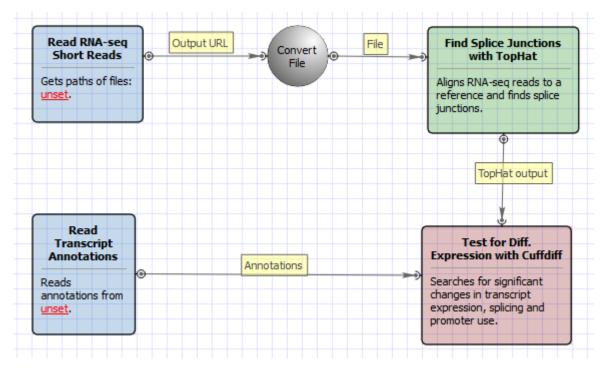
For Single-sample Tuxedo Pipeline analysis type and single-end reads type the following workflow appears:



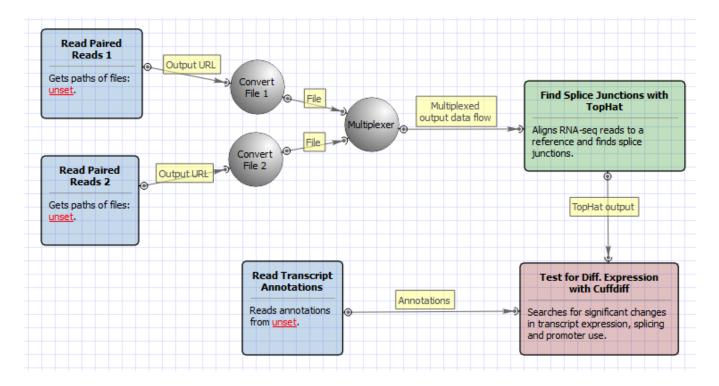
For Single-sample Tuxedo Pipeline analysis type and paired-end reads type the following workflow appears:



For No-new-transcripts Tuxedo Pipeline analysis type and single-end reads type the following workflow appears:



For No-new-transcripts Tuxedo Pipeline analysis type and paired-end reads type the following workflow appears:



Workflow Wizard

All of these workflows have the similar wizards. For Full Tuxedo Pipeline analysis type and paired-end reads type wizard has 7 pages.

1. Input data: Here you need to input RNA-seq short reads in FASTA or FASTQ formats. Many datasets with different reads can be added.

U Tuxedo Wizard		? ×
	Input data RNA-seq paired short reads Dataset 1 2 Dataset 2 3 First short-reads files	Second short-reads files
Defaults		Next > Cancel Help

2. <u>Cuffdiff Samples:</u> Here you need to divide the input datasets into samples for running Cuffdiff. There are must be at least 2 samples. It is not necessary to have the same number of datasets (replicates) for each sample. The samples names will be used by Cuffdiff as labels, which will be included in various output files produced by Cuffdiff.

U Tuxedo Wizard		? <mark>x</mark>
	Cuffdiff Samples	
	Divide the input datasets into samples for running Cuffdiff. There are must be at lea samples. It is not necessary to have the same number of datasets (replicates) for ex- sample. The samples names will be used by Cuffdiff as labels, which will be included is output files produced by Cuffdiff.	ach
	Sample 1	*
	Dataset 1 Sample2	
UGENE	Dataset 2	••••••••••••••••••••••••••••••••••••••
Defaults	< Back Next > Cancel	Help

3. <u>Tophat Settings:</u> Here you can configure TopHat settings. To show additional parameters click on the + button.

U Tuxedo Wizard			8 ×
Tuxedo Wizard	Tophat settings Tophat input Bowtie index directory Bowtie index basename Bowtie version Parameters Known transcript file Raw junctions Additional Show additional parameters	Required Required Bowtie2	Select bowte index file
		<back next=""> Can</back>	

The following parameters are available:

Bowti e index direct ory	The directory with the Bowtie index for the reference sequence.
Bowti e index base name	The basename of the Bowtie index for the reference sequence.

Bowti e versi on	Specifies which Bowtie version should be used.
Know n trans cript file	A set of gene model annotations and/or known transcripts.
Raw juncti ons	The list of raw junctions.
Mate inner dista nce	Expected (mean) inner distance between mate pairs.
Mate stand ard devia tion	Standard deviation for the distribution on inner distances between mate pairs.
Librar y type	Specifies RNA-seq protocol.
No novel juncti ons	Only look for reads across junctions indicated in the supplied GFF or junctions file. This parameter is ignored if Raw junctions or Known transcript file is not set.
Max multi hints	Instructs TopHat to allow up to this many alignments to the reference for a given read, and suppresses all alignments for reads with more than this many alignments.
Segm ent length	Each read is cut up into segments, each at least this long. These segments are mapped independently.
Fusio n search	Turn on fusion mapping.
Trans crito me max hits	Only align the reads to the transcriptome and report only those mappings as genomic mappings.
Prefilt er multi hints	When mapping reads on the transcriptome, some repetitive or low complexity reads that would be discarded in the context of the genome may appear to align to the transcript sequences and thus may end up reported as mapped to those genes only. This option directs TopHat to first align the reads to the whole genome in order to determine and exclude such multi-mapped reads (according to the value of the Max multihits option).
Min anch or length	The anchor length. TopHat will report junctions spanned by reads with at least this many bases on each side of the junction. Note that individual spliced alignments may span a junction with fewer than this many bases on one side. However, every junction involved in spliced alignments is supported by at least one read with this many bases on each side.
Splic e mism atches	The maximum number of mismatches that may appear in the anchor region of a spliced alignment.
Read mism atches	Final read alignments having more than these many mismatches are discarded.
Segm ent mism atches	Read segments are mapped independently, allowing up to this many mismatches in each segment alignment.
Solex a 1.3 quals	As of the Illumina GA pipeline version 1.3, quality scores are encoded in Phred-scaled base-64. Use this option for FASTQ files from pipeline 1.3 or later.

Bowti e versi on	specifies which Bowtie version should be used.
Bowti e -n mode	TopHat uses -v in Bowtie for initial read mapping (the default), but with this option, -n is used instead. Read segments are always mapped using -v option.
Bowti e tool path	The path to the Bowtie external tool.
SAMt ools tool path	The path to the SAMtools tool. Note that the tool is available in the UGENE External Tool Package.
TopH at tool path	The path to the TopHat external tool in UGENE.
Temp orary direct ory	The directory for temporary files.

4. <u>Cufflinks Settings:</u> The following page allows one to configure Cufflinks settings:

U Tuxedo Wizard			? ×
	Cufflinks settings		
	Parameters Reference annotation		
	RABT annotation		
	Library type	Standard Illumina	•
	Mask file		
	Multi-read correct	False	•
	Min isoform fraction	0.10000	
	Frag bias correct		
	Pre-mRNA fraction	0.15000	
	Additional		
	Show additional parameters		+
Ugene			
Defaults		< Back Next > Cancel	Help

The following parameters are available:

Ref ere nce ann otat ion	Tells Cufflinks to use the supplied reference annotation to estimate isoform expression. Cufflinks will not assemble novel transcripts and the program will ignore alignments not structurally compatible with any reference transcript.
RA BT ann otat ion	Tells Cufflinks to use the supplied reference annotation to guide Reference Annotation Based Transcript (RABT) assembly. Reference transcripts will be tiled with faux-reads to provide additional information in an assembly. The output will include all reference transcripts as well as any novel genes and isoforms that are assembled.
	Specifies RNA-seq protocol.

Libr ary type	
Ma sk file	Ignore all reads that could have come from transcripts in this file. It is recommended to include any annotated rRNA, mitochondrial transcripts other abundant transcripts you wish to ignore in your analysis in this file. Due to variable efficiency of mRNA enrichment methods and rRNA depletion kits, masking these transcripts often improves the overall robustness of transcript abundance estimates.
Mul ti- rea d corr ect	Tells Cufflinks to do an initial estimation procedure to more accurately weight reads mapping to multiple locations in the genome.
Min isof orm frac tion	After calculating isoform abundance for a gene, Cufflinks filters out transcripts that it believes are very low abundance, because isoforms expressed at extremely low levels often cannot reliably be assembled, and may even be artifacts of incompletely spliced precursors of processed transcripts. This parameter is also used to filter out introns that have far fewer spliced alignments supporting them.
Fra g bia s corr ect	Providing Cufflinks with a multifasta file via this option instructs it to run the bias detection and correction algorithm which can significantly improve accuracy of transcript abundance estimates.
Pre - mR NA frac tion	Some RNA-Seq protocols produce a significant amount of reads that originate from incompletely spliced transcripts, and these reads can confound the assembly of fully spliced mRNAs. Cufflinks uses this parameter to filter out alignments that lie within the intronic intervals implied by the spliced alignments. The minimum depth of coverage in the intronic region covered by the alignment is divided by the number of spliced reads, and if the result is lower than this parameter value, the intronic alignments are ignored.
Cuf flin ks tool path	The path to the Cufflinks external tool in UGENE.
Te mp ora ry dire ctory	The directory for temporary files.

5. <u>Cuffmerge settings:</u> On this page, you can modify Cuffmerge parameters.

U Tuxedo Wizard			? ×
	Cuffmerge settings Parameters Minimum isoform fraction Reference annotation	0.05000	*
	Reference sequence Additional Show additional parameters		+
Defaults	< Ba	ck Next > Cancel	Help

The following parameters are available:

Minimum isoform fraction	Discard isoforms with abundance below this.
Reference annotation	Merge the input assemblies together with this reference annotation.
Reference sequence	The genomic DNA sequences for the reference. It is used to assist in classifying transfrags and excluding artifacts (e.g. repeats). For example, transcripts consisting mostly of lower-case bases are classified as repeats.
Cuffcompare tool path	The path to the Cuffcompare external tool in UGENE.
Cuffmerge tool path	The path to the Cuffmerge external tool in UGENE.
Temporary directory	The directory for temporary files.

6. <u>Cuffdiff settings:</u> On the following page you may configure Cuffdiff settings:

U Tuxedo Wizard			8 ×
Tuxedo Wizard	Cuffdiff settings Parameters Time series analysis Upper quartile norm Hits norm Frag bias correct Multi read correct Library type Additional Show additional parameters	False False Compatible True Standard Illumina	
Defaults		< Back Next > Cancel	Help

The following parameters are available:

Tim e seri es ana lysis	If set to True, instructs Cuffdiff to analyze the provided samples as a time series, rather than testing for differences between all pairs of samples. Samples should be provided in increasing time order.
Up per qua rtile norm	If set to True, normalizes by the upper quartile of the number of fragments mapping to individual loci instead of the total number of sequenced fragments. This can improve the robustness of differential expression calls for less abundant genes and transcripts.
Hits norm	Instructs how to count all fragments. Total specifies to count all fragments, including those not compatible with any reference transcript, towards the number of mapped fragments used in the FPKM denominator. Compatible specifies to use only compatible fragments. Selecting Compatible is generally recommended in Cuffdiff to reduce certain types of bias caused by differential amounts of ribosomal reads which can create the impression of falsely differentially expressed genes.
Fra g bia s corr ect	Providing the sequences your reads were mapped to instructs Cuffdiff to run bias detection and correction algorithm which can significantly improve the accuracy of transcript abundance estimates.
Mul ti rea d corr ect	Do an initial estimation procedure to more accurately weight reads mapping to multiple locations in the genome.
Libr ary type	Specifies RNA-Seq protocol.
Ma sk file	Ignore all reads that could have come from transcripts in this file. It is recommended to include any annotated rRNA, mitochondrial transcripts other abundant transcripts you wish to ignore in your analysis in this file. Due to variable efficiency of mRNA enrichment methods and rRNA depletion kits, masking these transcripts often improves the overall robustness of transcript abundance estimates.
Min alig nm	The minimum number of alignments in a locus for needed to conduct significance testing on changes in that locus observed between samples. If no testing is performed, changes in the locus are deemed not significant, and the locus' observed changes don't contribute to correction for multiple testing.

ent cou nt					
FDR	Allowed false discovery rate used in testing.				
Ma x ML E iter atio ns	Sets the number of iterations allowed during maximum likelihood estimation of abundances.				
Emi t cou nt tabl es	Include information about the fragment counts, fragment count variances, and fitted variance model into the report.				
Cuf fdiff tool path	The path to the Cuffdiff external tool in UGENE.				
Te mp orar y dire ctory	The directory for temporary files.				

7. <u>Output data:</u> On this page, you can modify output parameters.

U Tuxedo Wizard			? X
	Output	t data	
	Tools output	t directories	
	Tophat Cufflinks	tools_output	
	Cuffmerge	tools_output tools_output	
	Cuffdiff	tools_output	
Defaults		< Back Apply Cancel Run	Help

(1) The work on this pipeline was supported by grant RUB1-31097-NO-12 from NIAID.