CD151 (CD151 molecule (Raph blood group))

Identity

Other names
- CD151 antigen
- GP27
- MER2
- PETA-3
- PETA3
- PETA3F
- RAPH
- SFA-1
- SFA1
- TSPAN24
- Tspan-24
- Tetraspanin-24

HGNC (Hugo) CD151
Location 11p15.5
Location_base_pair Starts at 832952 and ends at 838834 bp from pter (according to hg19-Feb_2009) [Mapping]
Local_order Telomere--PNPLA2--EFCAB4A--CD151--POLR2L--TSPAN4--Centromere.

DNA/RNA

Note Information sourced from UCSC Genome Database Mar 2006 Assembly (hg18) RefSeq genes and from analysis of mouse gene organisation (Fitter et al., 1998) and human gene structure (Whittock et al., 2001).

![Gene Structure Diagram](https://atlasgeneticsoncology.org/Genes/CD151ID967ch11p15.html)

The red bars indicate utr and green bars indicate coding exons. The size of each intron is indicated at the top and each exon below. An alternate transcript may be generated from splicing out exon 2 in the 5'utr as indicated with the blue lines.

Description 5884 bp, 9 exons (7 coding).
Transcription mRNA 1574bp (length may vary for utr alternate splicing).
Pseudogene None in humans.
**Protein**

The red bars indicate transmembrane regions as predicted by TMHMM (Krogh et al., 2001), with the green circles palmitoylation sites (Berditchevski et al., 2002). The blue Y indicates an N-linked glycosylation site (Fitter et al., 1995) and the light blue lines indicate approximate sites of potential disulphide bridges (Seigneuret et al., 2001).

**Description**
Size: 253 aa, 28247 Da with a mature protein size of 32 kDa; pI: pH 7.44.
Post-translational modifications include disulphide bridges and an N-linked glycosylation site in the large extracellular loop and 6 palmitoylation sites.

**Expression**
Widely expressed, particularly on epithelial cells, endothelial cells, Schwann cells, muscle cells, megakaryocytes and platelets. Tissues typically display expression restricted to these cell types with lung, kidney, spleen, tonsil and cardiac muscle all having high levels. Low expression detected on fibroblasts, erythrocytes and leukocytes (Sincock et al., 1997).
Highly expressed (mRNA) in: heart, uterus, lung, prostate, liver (adult), spleen, placenta, pancreas.
Low/no expression (mRNA) in: foetal liver, brain, testes, ovaries.

**Localisation**
Plasma membrane, endosomes, endothelial cell junctions and hemidesmosomes in basal epithelial cells (Sincock et al., 1999; Sterk et al., 2000).

**Function**
CD151 is a major component of tetraspanin enriched microdomains, which are platforms for assembly of membrane signalling complexes (Hemler et al., 2005; Charrin et al., 2009). CD151 functions in signal transduction through forming direct complexes with integrins particularly alpha3beta1, alpha6beta1, alpha6beta4 and alphaIIbbeta3, thereby influencing a variety of cell functions including motility and adhesion which are outlined further below. CD151 also affects matrix metalloproteinase activity, with overexpression of CD151 in human melanoma cells resulting in increased expression of MMP9 (Hong et al., 2006). CD151 has been shown to interact with pro-matrix metalloproteinase 7 in osteoarthritic cartilage and regulate its activity (Fujita et al., 2006). In endothelial cells...
CD151 associates with the matrix metalloproteinase MT1-MMP and regulates its collagenolytic activity (Yañez-Mó et al., 2008).

**Homology**

Tetraspanin protein family. This protein family has 33 members in humans and is well conserved throughout vertebrates and also present in invertebrates. Key characteristics include the presence of 4 transmembrane domains with both N- and C-terminals in the cytoplasm, conserved cysteine-containing motifs and disulphide bonds in the large extra cellular loop and charged residues in the transmembrane domains.

**Mutations**

**Note**

Only 3 mutations have been identified in humans to date, two (G533A and C511T), are predicted not to significantly alter CD151 function and are not associated with disease (Karamatic Crew et al., 2004; Karamatic Crew et al., 2008).

**Germinal**

Homozygous 1bp insertion, G383, resulting in a frameshift at Lys127 and a truncated protein at codon 140.
Homozygous G533A substitution resulting in an Arg178His mutation.
Homozygous C511T substitution resulting in an Arg171His mutation.

**Implicated in**

**Note**

*In vitro studies*

In vitro assays on Cd151-null keratinocytes, showed lack of migration compared to wild-type keratinocytes (Geary et al., 2008). Over-expression and knock-down studies of CD151 in various cell lines generally show that CD151 promotes migration and adhesion, however these finding are influenced by cell type and extracellular matrix components and primarily appear to be modified by the expression of the integrin alpha3beta1 (Berditchevski et al., 2002; Winterwood et al., 2006; Liu et al., 2007; Yang et al., 2008). CD151 is down-regulated by HIF-1alpha in colon cancer cells and is re-expressed upon normal oxygenation. This is proposed to allow detachment from the primary tumour and re-attachment at sites of metastasis (Chien et al., 2008).

**Oncogenesis**

Increased CD151 expression may lead to enhanced tumour progression and metastatic capacity based on enhanced motility, migration and adhesion of CD151 expressing cells. Antibodies to CD151 blocked in vivo metastasis in model systems (Testa et al., 1999; Zijlstra et al., 2008). Xenograft breast cancer models involving silencing of CD151 showed a delay in tumour formation (Yang et al., 2008). CD151 expression is increased in metastasis compared to primary tumour site in colon cancer (Chien et al. 2008).

**Entity**

Prostate cancer

**Prognosis**

High CD151 expression was indicative of poor outcome.

**Note**

Immunohistochemical detection of CD151 in a prostate cancer tissue specimens had greater prognostic value than Gleason grading (Ang et al., 2004).

**Gingival squamous cell carcinoma**

**Note**

Real-time PCR analysis of CD151 gene expression compared to GAPDH was analysed (Hirano et al., 2009). Assessment of protein expression by immunohistochemistry correlated with gene expression however no statistical analyses were performed on protein expression.

**Prognosis**

High CD151 expression was indicative of poor outcome.
High CD151 expression indicated poor survival outcome, suggesting a role for CD151 in enhancing tumourigenesis or resistance to treatment. Also refer to 'In vitro studies'.

**Entity** Colon cancer

**Note** Real-time PCR analysis of CD151 gene expression compared to beta-actin was analysed (Hashida et al., 2003). Assessment of protein expression by immunohistochemistry correlated with gene expression however no statistical analyses were performed on protein expression.

**Prognosis** High CD151 expression was indicative of poor outcome.

**Oncogenesis** High CD151 expression indicated poor survival outcome, suggesting a role for CD151 in enhancing tumourigenesis or resistance to treatment. Also refer to 'In vitro studies'.

**Entity** Hepatocellular carcinoma

**Note** Real-time PCR analysis of CD151 gene expression compared to GAPDH was analysed. Assessment of protein expression by immunohistochemistry and immunoblotting generally correlated with gene expression. CD151 expression was increased in hepatocellular carcinomas compared to normal liver tissues (Ke et al., 2009). Immunohistochemical analysis of tissue microarrays identified a positive correlation between CD151 expression and aggressive histopathological factors such as vascular invasion and poor tumour differentiation. CD151 expression was also indicative of poor outcome (Ke et al., 2009).

**Prognosis** High CD151 expression was indicative of poor outcome.

**Oncogenesis** High CD151 expression indicated poor survival outcome, suggesting a role for CD151 in enhancing tumourigenesis or resistance to treatment. Also refer to 'In vitro studies'.

**Entity** Non-small cell lung carcinoma

**Note** Real-time PCR analysis of CD151 gene expression compared to beta-actin was analysed (Tokuhara et al., 2001). Assessment of protein expression by immunohistochemistry correlated with gene expression however no statistical analyses were performed on protein expression.

**Prognosis** High CD151 expression was indicative of poor outcome.

**Oncogenesis** High CD151 expression indicated poor survival outcome, suggesting a role for CD151 in enhancing tumourigenesis or resistance to treatment. Also refer to 'In vitro studies'.

**Entity** Breast cancer

**Note** Immunohistochemical analysis of CD151 expression in a cohort of invasive ductal carcinoma identified a significantly higher risk of death from breast cancer in CD151 positive tumours compared to CD151 negative tumours. CD151 expression was also positively associated with the involvement of regional lymph nodes. No associations between CD151 expression and other clinical factors including estrogen receptor status were found (Sadej et al., 2009). Immunohistochemical analysis of CD151 in breast tissue Microarrays identified positive correlations between CD151 expression and high tumour grade as well as negativity for the estrogen receptor. No other associations were identified between CD151 expression and clinical factors (Yang et al., 2008). Associations between CD151 expression and outcome were not able to be made due to unavailability of data.

**Prognosis** High CD151 expression was indicative of poor outcome.

**Oncogenesis** High CD151 expression indicated poor survival outcome, suggesting a role for CD151 in enhancing tumourigenesis or resistance to treatment. Also refer to 'In vitro studies'.
**Entity**

Pancreatic cancer

**Note**

Immunohistochemical analysis of pancreatic cancer cell lines and pancreatic tumors identified high CD151 expression associated with tumors/cell lines compared to normal tissue. Tumor stroma also expressed CD151 (Geiserich et al., 2005).

**Oncogenesis**

Refer to 'In vitro studies'.

**Entity**

Neovascularisation/Pathologic Angiogenesis

**Note**

Determined from in vivo studies in Cd151-null mice and in vitro studies of Cd151-null mouse lung endothelial cells (Takeda et al., 2007). Analysis of a rat myocardial ischaemia model also showed that viral delivery of CD151 can promote neovascularisation (Zheng and Liu, 2006).

**Disease**

Cancer, ischaemia

**Oncogenesis**

Lack of Cd151 expression resulted in impaired tumour angiogenesis, suggesting that Cd151 may be involved in promoting tumour angiogenesis.

**Entity**

Nephropathy

**Note**

CD151 is expressed normally in the kidney particularly in the glomerular basement membrane (Sincock et al., 1997).

**Disease**

Nephropathy in humans (Karamatic Crew et al., 2004).

Cd151-null mice develop progressive renal failure on the FVB/N strain but not the C57BL/6 strain (Sachs et al., 2006; Baleato et al., 2008).

**Prognosis**

Loss of CD151 activity leads to chronic renal failure.

**Cytogenetics**

Homozygous frameshift mutation causing a premature stop codon (codon 140) due to the insertion of 1bp in exon 5 of CD151 (G383).

**Gene**

CD151/MER2 antigen (Karamatic Crew et al., 2004).

**Entity**

Pretibial epidermolysis bullosa

**Note**

The Nephropathy described above is attributed to the same mutation in CD151 and occurs in conjunction with pretibial epidermolysis bullosa and deafness (Karamatic Crew et al., 2004).

Wound repair in wild-type mice is associated with an up-regulation of Cd151 in the migrating epidermis at the wound edge (Cowin et al. 2006).

**Disease**

Pretibial epidermolysis bullosa in humans.

Defective wound repair in Cd151-null mice (Cowin et al. 2006; Geary et al 2008).

**Cytogenetics**

Homozygous frameshift mutation causing a premature stop codon (codon 140) due to the insertion of 1bp in exon 5 of CD151 (G383).

**Gene**

CD151/MER2 antigen.

**Entity**

Deafness

**Note**

This loss of function of CD151 is attributed to the same mutation in CD151 as that described above for nephropathy and pretibial epidermolysis bullosa, with all 3 disorders occurring in the same patients (Karamatic Crew et al., 2004).

**Prognosis**

Progressive deafness occurring by early adulthood.

**Cytogenetics**

Homozygous frameshift mutation causing a premature stop codon (codon 140) due to the insertion of 1bp in exon 5 of CD151 (G383).

**Gene**

CD151/MER2 antigen.
As assessed in Cd151-null mice, loss of Cd151 caused increased bleeding time and decreased clotting ability, suggesting endothelial and/or platelet cell functional defects. Cd151-null mice did not show any overt physiological differences unless challenged (Wright et al., 2004). Further in vitro analysis of Cd151-null platelets showed impaired functions relating to aggregation, spreading and clot retraction (Lau et al., 2004).

**External links**

<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>HGNC (Hugo)</th>
<th>CD151 1630</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrez Gene (NCBI)</td>
<td>CD151 977</td>
<td>CD151 molecule (Raph blood group)</td>
</tr>
<tr>
<td>Cards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atlas</td>
<td>CD151ID967ch11p15</td>
<td></td>
</tr>
<tr>
<td>GeneCards (Weizmann)</td>
<td></td>
<td>CD151</td>
</tr>
<tr>
<td>Ensembl (Hinxton)</td>
<td>ENSG00000177697 [Gene_View] chr11:832952-838834 [Contig_View] CD151 [Vega]</td>
<td></td>
</tr>
<tr>
<td>AceView (NCBI)</td>
<td>CD151</td>
<td></td>
</tr>
<tr>
<td>Genatlas (Paris)</td>
<td>CD151</td>
<td></td>
</tr>
<tr>
<td>euGene (Indiana)</td>
<td>977</td>
<td></td>
</tr>
<tr>
<td>SOURCE (Stanford)</td>
<td>NM_001039490 NM_004357 NM_139029 NM_139030</td>
<td></td>
</tr>
</tbody>
</table>

**Genomic and cartography**

- GoldenPath (UCSC): CD151 - 11p15.5 chr11:832952-838834 + 11p15.5 [Description] (hg19-Feb_2009)
- Ensembl: CD151 - 11p15.5 [CytoView]

**Gene and transcription**

- Genbank (Entrez): AK130369 AK223186 AK293073 AL161965 AU099249
- RefSeq transcript (SRS): NM_001039490 NM_004357 NM_139029 NM_139030
- RefSeq transcript (Entrez): NM_001039490 NM_004357 NM_139029 NM_139030
- RefSeq genomic (SRS): AC_000054 AC_000143 NC_000011 NG_007478 NT_009237 NW_001838016 NW_924962
- RefSeq genomic (Entrez): AC_000054 AC_000143 NC_000011 NG_007478 NT_009237 NW_001838016 NW_924962

**Consensus coding sequences : CCDS (NCBI)**

- CD151

**Cluster EST : Unigene**

- Hs.654379 [SRS] Hs.654379 [NCBI]

**Alternative Splicing :**

- 444

**Gene Expression**

- CD151 [NCBI-GEO] CD151 [EBI - ARRAY_EXPRESS]
### Protein: pattern, domain, 3D structure

- **UniProt/SwissProt**: P48509 (SRS) P48509 (Expasy) P48509 (Uniprot)
- **With graphics**: P48509
- **Splice isoforms**: P48509 (VarSplice FASTA)
- **Domain pattern**: TM4_1 (PS00421)
- **Domain pattern**: TM4_1 (PS00421)
- **Domains**: Interpro (SRS) Tetraspanin Tetraspanin_CS Tetraspanin_EC2 Tetraspanin_sub
- **Domains**: Interpro (EBI) Tetraspanin Tetraspanin_CS Tetraspanin_EC2 Tetraspanin_sub
- **Related proteins**: CluSTr P48509
- **Domain families**: Pfam (SRS) Tetraspannin (PF00335) Pfam (Sanger) Tetraspannin (PF00335) Pfam (NCBI) pfam00335
- **Blocks (Seattle)** P48509
- **PDB**: PDB (SRS) PDB (PDBsum) PDB (IMB) PDB (RSDB)
- **Human Protein Atlas**: ENSG00000177697 03763
- **HPRD**: P48509

### Protein Interaction databases

- **DIP (DOE-UCLA)** P48509
- **IntAct (EBI)** P48509
- **FunCoup**: ENSG00000177697
- **REACTOME**: CD151

### Polymorphism: SNP, mutations, diseases

- **SNP Single Nucleotide Polymorphism (NCBI)**: CD151
- **SNP (GeneSNP Utah)**: CD151
- **SNP: HGBase**: CD151
- **Genetic variants**: CD151
- **Somatic Mutations in Cancer: COSMIC**: CD151
- **CONAN: Copy Number Analysis**: CD151
<table>
<thead>
<tr>
<th>Mutations and Diseases : HGMD</th>
<th>CD151</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMIM</td>
<td>179620 602243 609057</td>
</tr>
<tr>
<td>GENETests</td>
<td>179620 602243 609057</td>
</tr>
<tr>
<td>Disease Genetic Association</td>
<td>CD151</td>
</tr>
<tr>
<td>Genomic Variants</td>
<td>CD151</td>
</tr>
</tbody>
</table>

General knowledge

<table>
<thead>
<tr>
<th>Homologs : HomoloGene</th>
<th>CD151</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homology/Alignments</td>
<td>CD151</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phylogenetic Trees/Animal Genes : TreeFam</th>
<th>CD151</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical/Protein Interactions : CTD</td>
<td>977</td>
</tr>
<tr>
<td>Ontology : AmiGO</td>
<td>protein binding, membrane fraction, cytosol, plasma membrane, integral to plasma membrane, cell adhesion, hemidesmosome assembly</td>
</tr>
<tr>
<td>Ontology : EGO-EBI</td>
<td>protein binding, membrane fraction, cytosol, plasma membrane, integral to plasma membrane, cell adhesion, hemidesmosome assembly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pathways : BIOCARTA</th>
<th>CD151</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathways : KEGG</td>
<td></td>
</tr>
</tbody>
</table>

Other databases

<table>
<thead>
<tr>
<th>Probes : Imagenes</th>
<th>CD151 Related clones (RZPD - Berlin)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>PubMed</th>
<th>63 Pubmed reference(s) in Entrez</th>
</tr>
</thead>
<tbody>
<tr>
<td>PubGene</td>
<td>CD151</td>
</tr>
</tbody>
</table>

Bibliography

Molecular cloning of cDNA encoding a novel platelet-endothelial cell tetra-span antigen, PETA-3.
Fitter S, Tetaz TJ, Berndt MC, Ashman LK.
PMID 7632941

Localization of the transmembrane 4 superfamily (TM4SF) member PETA-3 (CD151) in normal human tissues: comparison with CD9, CD63, and alpha5beta1 integrin.
Sincock PM, Mayrhofer G, Ashman LK.
PMID 9111230

Characterisation of the mouse homologue of CD151 (PETA-3/SFA-1); genomic structure, chromosomal localisation and identification of 2 novel splice forms.
Fitter S, Seldin MF, Ashman LK.
PMID 9602068
PETA-3/CD151, a member of the transmembrane 4 superfamily, is localised to the plasma membrane and endocytic system of endothelial cells, associates with multiple integrins and modulates cell function.
Sincock PM, Fitter S, Parton RG, Berndt MC, Gamble JR, Ashman LK.
PMID 10036233

Eukaryotic expression cloning with an antimetastatic monoclonal antibody identifies a tetraspanin (PETA-3/CD151) as an effector of human tumor cell migration and metastasis.
Testa JE, Brooks PC, Lin JM, Quigley JP.
PMID 10447000

The tetraspan molecule CD151, a novel constituent of hemidesmosomes, associates with the integrin alpha6beta4 and may regulate the spatial organization of hemidesmosomes.
Sterk LM, Geuijen CA, Oomen LC, Calafat J, Janssen H, Sonnenberg A.
PMID 10811835

Predicting transmembrane protein topology with a hidden Markov model: application to complete genomes.
Krogh A, Larsson B, von Heijne G, Sonnhammer EL.
PMID 11152613

Structure of the tetraspanin main extracellular domain. A partially conserved fold with a structurally variable domain insertion.
Seigneuret M, Delaguillaumie A, Lagaudriere-Gesbert C, Conjeaud H.
PMID 11483611

Tokuhara T, Hasegawa H, Hattori N, Ishida H, Taki T, Tachibana S, Sasaki S, Miyake M.
PMID 11751509

Genomic organization, amplification, fine mapping, and intragenic polymorphisms of the human hemidesmosomal tetraspanin CD151 gene.
Whittock NV, McLean WH.
PMID 11181065

Expression of the palmitoylation-deficient CD151 weakens the association of alpha 3 beta 1 integrin with the tetraspanin-enriched microdomains and affects integrin-dependent signaling.
Berditchevski F, Odintsova E, Sawada S, Gilbert E.
PMID 12110679

Clinical significance of transmembrane 4 superfamily in colon cancer.
PMID 12838318
CD151 protein expression predicts the clinical outcome of low-grade primary prostate cancer better than histologic grading: a new prognostic indicator?
Ang J, Lijovic M, Ashman LK, Kan K, Frauman AG.
PMID 15533898

CD151, the first member of the tetraspanin (TM4) superfamily detected on erythrocytes, is essential for the correct assembly of human basement membranes in kidney and skin.
PMID 15265795

The tetraspanin superfamily member CD151 regulates outside-in integrin alphaIIbbeta3 signaling and platelet function.
Lau LM, Wee JL, Wright MD, Moseley GW, Hogarth PM, Ashman LK, Jackson DE.
PMID 15226180

Characterization of mice lacking the tetraspanin superfamily member CD151.
PMID 15199151

Colocalization of the tetraspanins, CO-029 and CD151, with integrins in human pancreatic adenocarcinoma: impact on cell motility.
PMID 15837731

Tetraspanin functions and associated microdomains.
Hemler ME.
PMID 16314869

Wound healing is defective in mice lacking tetraspanin CD151.
Cowin AJ, Adams D, Geary SM, Wright MD, Jones JC, Ashman LK.
PMID 16410781

Tetraspanin CD151 is expressed in osteoarthritic cartilage and is involved in pericellular activation of pro-matrix metalloproteinase 7 in osteoarthritic chondrocytes.
Fujita Y, Shiomi T, Yanagimoto S, Matsumoto H, Toyama Y, Okada Y.
PMID 17009258

Homophilic interactions of Tetraspanin CD151 up-regulate motility and matrix metalloproteinase-9 expression of human melanoma cells through adhesion-dependent c-Jun activation signaling pathways.
Hong IK, Jin YJ, Byun HJ, Jeoung DI, Kim YM, Lee H.
PMID 16798740

Kidney failure in mice lacking the tetraspanin CD151.

A critical role for tetraspanin CD151 in alpha3beta1 and alpha6beta4 integrin-dependent tumor cell functions on laminin-5.

CD151 gene delivery activates PI3K/Akt pathway and promotes neovascularization after myocardial infarction in rats.

Tetraspanin CD151 promotes cell migration by regulating integrin trafficking.

Deletion of tetraspanin Cd151 results in decreased pathologic angiogenesis in vivo and in vitro.

Deletion of CD151 results in a strain-dependent glomerular disease due to severe alterations of the glomerular basement membrane.

Regulation of CD151 by hypoxia controls cell adhesion and metastasis in colorectal cancer.

The role of the tetraspanin CD151 in primary keratinocyte and fibroblast functions: implications for wound healing.

Two MER2-negative individuals with the same novel CD151 mutation and evidence for clinical significance of anti-MER2.

MT1-MMP collagenolytic activity is regulated through association with tetraspanin CD151 in primary endothelial cells.
CD151 accelerates breast cancer by regulating alpha 6 integrin function, signaling, and molecular organization.
Cancer Res. 2008 May 1;68(9):3204-13.
PMID 18451146

The inhibition of tumor cell intravasation and subsequent metastasis via regulation of in vivo tumor cell motility by the tetraspanin CD151.
Zijlstra A, Lewis J, Degryse B, Stuhlmann H, Quigley JP.
Cancer Cell. 2008 Mar;13(3):221-34.
PMID 18328426

Lateral organization of membrane proteins: tetraspanins spin their web.
Charrin S, le Naour F, Silvie O, Milhiet PE, Boucheix C, Rubinstein E.
Biochem J. 2009 May 13;420(2):133-54. (REVIEW)
PMID 19426143

Tetraspanin gene expression levels as potential biomarkers for malignancy of gingival squamous cell carcinoma.
PMID 19330835

Role of overexpression of CD151 and/or c-Met in predicting prognosis of hepatocellular carcinoma.
PMID 19065669

CD151 regulates tumorigenesis by modulating the communication between tumor cells and endothelium.
PMID 19531562

Last year publications  automatic search in PubMed
REVIEW articles  automatic search in PubMed
Search in all EBI   NCBI

Contributor(s)

Written 07-2009  Judith Weidenhofer, Leonie K Ashman
Medical Biochemistry, School of Biomedical Sciences and Pharmacy, University of Newcastle, NSW, Australia

Citation

This paper should be referenced as such: