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# Cellular mechanisms that establish HIV-1 latency in CD4+ T cells and the potential for their manipulation as a therapeutic strategy

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BOSTON UNIVERSITY  
SCHOOL OF MEDICINE

Dissertation

**CELLULAR MECHANISMS THAT ESTABLISH HIV-1 LATENCY IN CD4+ T  
CELLS AND THE POTENTIAL FOR THEIR MANIPULATION AS A  
THERAPEUTIC STRATEGY**

by

**MATTHEW GAGNE**

B.A., Boston University, 2009

Submitted in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

2019



Approved by

First Reader

---

Andrew J. Henderson, Ph.D.  
Associate Professor of Medicine  
Associate Professor of Microbiology

Second Reader

---

Suryaram Gummuluru, Ph.D.  
Associate Professor of Microbiology

*“Every great and deep difficulty bears in itself its own solution. It forces us to change our thinking in order to find it.”*

*- Attributed to Niels Bohr, Ph.D.*

*Nobel Laureate, 1922*

## **DEDICATION**

For my parents, James and Monique Gagne, who introduced me to research.

For my mentors and classmates, who inspired me to persevere through my research.

For Myung-Eun, my life long research partner.

## ACKNOWLEDGMENTS

The work presented in this dissertation is the result of years spent in the lab surrounded by postdoctoral researchers, fellow graduate students, technicians, and mentors without whom none of this would have been possible. While there are many individuals who contributed to my progress both scientifically and educationally, I would particularly like to thank Luis Agosto, Ph.D., who extensively helped with my nested *Alu*-PCR and cell sorting strategies, and Gillian Schiralli Lester, Ph.D., who helped formulate some of the earliest iterations of this work. Two former graduate students, Katarzyna Kaczmarek Michaels, Ph.D., and Daniele Cary, Ph.D., also provided extensive guidance regarding experimental techniques and the graduate school process. Dan Michaels performed the chromatin immunoprecipitations described in this dissertation and entertained me with hilarious stories on the slowest days in lab. Alex Olson and Binita Basukala worked tirelessly on the disabled Cas9 experiments and were great labmates; I look forward to seeing where their scientific careers take them. Kyle Pedro was my fellow Microbiology graduate student in the Henderson lab and a constant advocate for improved science policies. Melissa Herring, Hasahn Conway, Carolyn Coote, and Xianbao He were all amazing lab members and thoughtful scientists. Finally, I owe most of my progress as a scientist to my mentor, Andrew J. Henderson, Ph.D., who provided constructive criticism and softened the blow with his unlimited supply of bagels, Chinese pastries, and Blackbird doughnuts. He spent countless hours not only by helping me design my experiments, but also by teaching me about grant writing, career

development, and presentation skills. I am a much better scientist because I was in his laboratory.

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**CELLULAR MECHANISMS THAT ESTABLISH HIV-1 LATENCY IN CD4+ T  
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**MATTHEW GAGNE**

Boston University School of Medicine, 2019

Major Professor: Andrew J. Henderson, Ph.D., Associate Professor of Medicine and  
Microbiology

**ABSTRACT**

Human Immunodeficiency Virus 1 (HIV-1) remains a significant public health concern due to the lack of a cure. In spite of anti-retroviral therapies, HIV-1 persists within infected cells as integrated transcriptionally silent proviruses. Re-activation after therapy interruption results in new HIV-1 replication. Attempts to clear this reservoir through the use of latency reversing agents by targeting cellular mechanisms that maintain HIV-1 in a latent state have been unsuccessful. In addition, subsets of latently infected cells exist within the reservoir that display differential capacities for provirus induction. In order to understand the nature of the reservoir and manipulate it therapeutically, more knowledge is needed regarding factors that bias a virus towards latency or replication at the time of infection.

Because multiple mechanisms that regulate HIV-1 transcription, including chromatin remodeling, transcription factor activation and polymerase pausing, are regulated by the T cell receptor (TCR), I hypothesized that signaling at the time of infection determines proviral fate. I transduced Jurkat cell lines and primary CD4+ T

cells with chimeric antigen receptors (CARs) that mimicked signaling from the TCR. These CARs spanned a 3-log range of binding affinities for their ligand, providing a tunable model. High levels of TCR stimulation during infection biased cells towards productive replication and the formation of an inducible latent reservoir. Examination of the mechanisms downstream from TCR signaling revealed that robust cellular activation led to a release of the repressor Negative Elongation Factor from the paused RNA Polymerase II, facilitating transcriptional elongation.

Because signaling determined the presence of repressive factors, I sought to manipulate the balance between latency and expression through recruitment of repressors to the HIV-1 provirus using a nuclease-deficient CRISPR Associated Protein 9 fused to a Krüppel Associated Box Domain. I screened a pool of guide RNAs that mediated transcriptional repression of HIV-1. Our lab discovered that guides bound to the HIV-1 Long Terminal Repeat prevented viral re-activation in an integrated cell model of HIV-1 latency.

The research presented here confirms my hypothesis that signals during infection have prolonged effects on latency reversal. I provide evidence that manipulation of these mechanisms represent therapeutic targets for cure efforts.

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## LIST OF ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
ANOVA	Analysis of Variance
AP-1	Activator Protein 1
APC	Antigen-Presenting Cell
ART	Antiretroviral Therapy
BET	Bromodomain and Extra-Terminal Motif
BRD4	Bromodomain-Containing Protein 4
BU	Boston University
CAR	Chimeric Antigen Receptor
cART	Combination Antiretroviral Therapy
dCas9	Disabled (Nuclease-Deficient) CRISPR Associated Protein 9
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
DSIF	DRB Sensitivity Inducing Factor
Efz	Efavirenz
ELISA	Enzyme-Linked Immunosorbent Assay
ESCRT	Endosomal Sorting Complexes Required for Transport
FDR	False Discovery Rate
$\gamma\delta$	Gammadelta T Cells
GFP	Green Fluorescent Protein
HATs	Histone Acetyltransferases
HDAC	Histone Deacetylase

HDACi .....	Histone Deacetylase Inhibitor
Her2.....	Human Epidermal Growth Factor Receptor 2
HIV-1 .....	Human Immunodeficiency Virus 1
HMT.....	Histone Methyltransferase
HUSH.....	Human Silencing Hub
ITAM .....	Immunoreceptor Tyrosine-Based Activation Motif
Kap1 .....	KRAB-Associated Protein-1 (Trim28)
KRAB .....	Krüppel Associated Box Domain
LAT.....	Linker of Activated T Cells
Lck .....	Lymphocyte-Specific Protein Tyrosine Kinase
LRA.....	Latency Reversing Agent
LTR.....	Long Terminal Repeat
MAPK.....	Mitogen-Activated Protein Kinase
MHC .....	Major Histocompatibility Complex
NF- $\kappa$ B .....	Nuclear Factor Kappa-Light-Chain-Enhancer of Activated B Cells
NFAT .....	Nuclear Factor of Activated T Cells
Nef.....	HIV Negative Regulatory Factor
NELF.....	Negative Elongation Factor
PBMCs.....	Peripheral Blood Mononuclear Cells
PHA .....	Phytohaemagglutinin
PKC.....	Protein Kinase C
PLC $\gamma$ 1 .....	Phosphoinositide Phospholipase C Gamma 1

PMA	Phorbol Myristate Acetate
PrEP	Pre-Exposure Prophylaxis
PtdIns(4,5)P <sub>2</sub>	Phosphatidylinositol 4,5-Bisphosphate
P-TEFb	Positive Transcription Elongation Factor
RNAPII	RNA Polymerase II
SAHA	Suberanilohydroxamic Acid (Vorinostat)
SBHA	Suberoyl Bis-Hydroxamic Acid
scFv	Single-Chain Variable Fragment
Sh2	Src Homology 2
SIV	Simian Immunodeficiency Virus
SP1	Specificity Protein 1
Src	Proto-Oncogene Tyrosine-Protein Kinase Src
SWI/SNF	Switch / Sucrose Non-Fermentable
Tat	HIV Transactivator of Transcription
TCR	T Cell Receptor
TNF $\alpha$	Tumor Necrosis Factor Alpha
VOA	Viral Outgrowth Assay
Vpr	HIV Viral Protein R
Vpx	HIV Viral Protein X
VSVG	Vesicular Stomatitis Virus Envelope Glycoprotein G
Zap70	Zeta-Chain-Associated Protein Kinase 70

## CHAPTER ONE: INTRODUCTION

### **The Emergence and Pathology of Human Immunodeficiency Virus-1**

Human Immunodeficiency Virus-1 (HIV-1) was first reported in a notice from the Centers of Disease Control on June 5, 1981 (CDC, 1981). This medical newsletter, which identified an outbreak of *Pneumocystis* pneumonia among homosexual men in Los Angeles, quickly brought attention to the spread of a contagious immunodeficiency. The underlying immune dysfunction, Acquired Immunodeficiency Syndrome, would later be discovered to be caused by the virus now known as HIV-1 (Gallo and Montagnier, 2003).

HIV-1 evolved from SIV or Simian Immunodeficiency Virus (Ringler *et al.*, 1987; Smith *et al.*, 1988). SIV consists of several species-specific strains that circulate among non-human primates, usually resulting in minimal symptoms and long-term tolerance (Bostik *et al.*, 2001). Cross-species jumps of these various strains from non-human primates into human hosts have led to the emergence of both HIV-1 and the related virus HIV-2. HIV-1 shares significant homology with the chimpanzee variant of SIV, known as SIVcpz, and most likely originated in central Africa in the first half of the 20<sup>th</sup> century (Gao *et al.*, 1999). The HIV-1 major groups M, N, O, and P arose from separate evolutionary cross-over events from SIVcpz or SIVgor (gorilla) and required the acquisition of the ability to inhibit key human restriction factors, so named for the ability to restrict viral replication (Sauter and Kirchhoff, 2019). In particular, HIV-1 Group M, which evolved from SIVcpz, can robustly inhibit a key restriction factor, tetherin, and

thus constitutes the majority of viruses responsible for the current human pandemic (Sauter *et al.*, 2009)

HIV-1 spread to North America due to increased travel and globalized commerce in the mid-1900's. Once in the United States, the virus spread quickly among Haitian immigrants, men who have sex with men (MSM), and hemophiliacs, who were susceptible to infection due to their need for frequent blood transfusions (De Cock, Jaffe and Curran, 2012). Mass hysteria over both the source of AIDS as well as the mode of transmission led to a concerted effort by the National Institutes of Health, the Centers for Disease Control, and the Institut Pasteur in Paris to fund AIDS-related research. These experiments culminated in the landmark discovery of HIV-1 in 1983 as the causative agent of AIDS in North America and Europe by Luc Montagnier and Françoise Barré-Sinoussi (Barré-Sinoussi *et al.*, 1983).

We now know that HIV-1 results in a depletion of the lymphocytic CD4+ T cell population. This weakens the adaptive immune response, rendering the host vulnerable to a wide variety of opportunistic infections (Frazer *et al.*, 1986; Shearer *et al.*, 1986). Early AIDS-identifying diseases included *Pneumocystis pneumonia*, Kaposi's sarcoma, and toxoplasmosis from *Toxoplasma gondii* (Pitchenik *et al.*, 1983). With the advent of antiretroviral therapies or ART in 1986, remarkable progress has been achieved in preventing the onset of AIDS (Mitsuya *et al.*, 1985). This progress was particularly enhanced with the design of combination therapy involving cocktails of inhibitors (Tisdale *et al.*, 1993). However, in spite of cART, lifelong infection with HIV-1 still results in greater risk of cardiovascular disease, kidney failure, and neurocognitive

impairments (Freiberg *et al.*, 2013; Guaraldi *et al.*, 2011; Simioni *et al.*, 2010). Patients experience permanent immune dysfunction, even after full viral suppression. Persistent exposure to viral antigens results in both immune exhaustion and constant inflammation (Hunt *et al.*, 2003; French *et al.*, 2009; Hatano *et al.*, 2013). Antiretroviral therapies, while essential to prevent progression to AIDS, also cause a number of serious side effects including loss of bone density, gastrointestinal discomfort, and hypersensitivity (Güerri-Fernández *et al.*, 2017; Santos *et al.*, 2017; Wu *et al.*, 2017).

The use of Truvada as pre-exposure prophylaxis (PrEP) beginning in 2012 has dramatically changed the trajectory of the HIV public health epidemic. Prescribing Truvada to high-risk populations has substantially reduced the spread of the virus (Grant *et al.*, 2010). However, neither cART nor PrEP has resulted in a cure for HIV-1 or the end of its transmission. In fact, although new infections of HIV-1 within the United States have plateaued, infection with HIV-1 is still a matter of much stigma and remains prevalent both in poorer regions of the southeastern United States (CDC, 2018) as well as Southeast Asia, Eastern Europe, and sub-Saharan Africa (Stuart *et al.*, 2018). Seventy percent of all HIV cases occur in sub-Saharan Africa where access to PrEP is extremely limited (Kharsany and Karim, 2016). Other groups that are still particularly susceptible to infection include MSM, sex-workers, IV-drug users, and minority women (CDC, 2018; UNAIDS, Guidance Note on HIV and Sex Work, 2019). Even with proper education and increased societal awareness, adherence to medication remains a major barrier to viral suppression. Thus, eradication of HIV-1 remains a significant challenge. The United Nations has prioritized a strategy, referred to as 90-90-90, in which the global medical

community aims to achieve 90% diagnosis of HIV, 90% ART-treatment among those diagnoses, and 90% viral suppression among those taking ART (Stover *et al.*, 2016). In tandem with this approach, there have been significant efforts to create a broad spectrum HIV-1 vaccine, but none of these strategies have so far completely prevented the spread of HIV-1 or led to a cure (Rerks-Ngarm *et al.*, 2009; Gray *et al.*, 2011). These factors all indicate that continued efforts must be made to eradicate HIV-1 and end both the terrible medical burden and social stigma caused by this virus. At the time of this publication, more than 35 million people have died from AIDS-related illnesses, including 1 million people in 2017 alone (UNAIDS, Global HIV & AIDS Statistics, 2019).

### **The Life Cycle of HIV-1**

When HIV-1 enters the human body, it is presumably trafficked through the mucosa by antigen-presenting cells or APCs (Hladik *et al.*, 2007). These APCs, including dendritic cells, Langerhans cells, and macrophages, play an important role in bridging the innate and adaptive immune responses. They endocytose pathogens before trafficking them to the cell surface in conjunction with an MHC Class II complex (Roche and Furuta, 2015). This presentation along with secondary stimulation by cytokines or cell surface receptors can trigger a specific response in lymphocytes for which the epitope of interest acts as the cognate antigen.

Eventually, HIV-1 is delivered by APCs to the lymph nodes, where it spreads to various target cells including macrophages, dendritic cells, and the primary reservoir of

CD4<sup>+</sup> T cells (Barré-Sinoussi *et al.*, 1983; Armstrong and Horne, 1984; Koenig *et al.*, 1986). The fact that HIV-1 can infect the APCs that present it to its various target cells highlight the dual role that can occur within dendritic cells and macrophages. Both direct infection and trans-infection through antigen presentation provide two routes through which HIV-1 can spread and highlight the importance of cell interactions to viral transmission (Cameron *et al.*, 1992; McDonald *et al.*, 2003). For dendritic cells, the differentiation state determines which of these routes can occur; for instance, trans-infection via CD169, a cell surface lectin, is associated with mature DCs (Puryear *et al.*, 2013).

HIV-1 target cells contain the necessary receptors for viral entry: CD4 and a coreceptor of CCR5 or CXCR4 (Feng *et al.*, 1996; Deng *et al.*, 1996; Dragic *et al.*, 1996). Founder viruses use CCR5 for viral entry and are referred to as R5-tropic. The progression to dual-tropic or X4-tropic viruses, which exclusively use CXCR4 for entry, is associated with both onset of AIDS and a depletion of R5-expressing cells (Connor *et al.*, 1997). This coreceptor switch does not occur in all HIV-infected patients.

The HIV-1 virion is spherical and marked by a limited number of glycoprotein envelope spikes (Zhu *et al.*, 2006). It consists of a lipid membrane derived from its previous host cell (Nguyen *et al.*, 2000) and contains an internal capsid harboring two copies of its genome as viral RNA (Chen *et al.*, 2009). In addition, it packages essential proteins for its replication, including reverse transcriptase, integrase, and its transcription factor Tat (Huang *et al.*, 1994; Bosso *et al.*, 2015; Kessl *et al.*, 2016). In addition, the viral accessory protein Vpr or Viral Protein R is also packaged and is required for robust

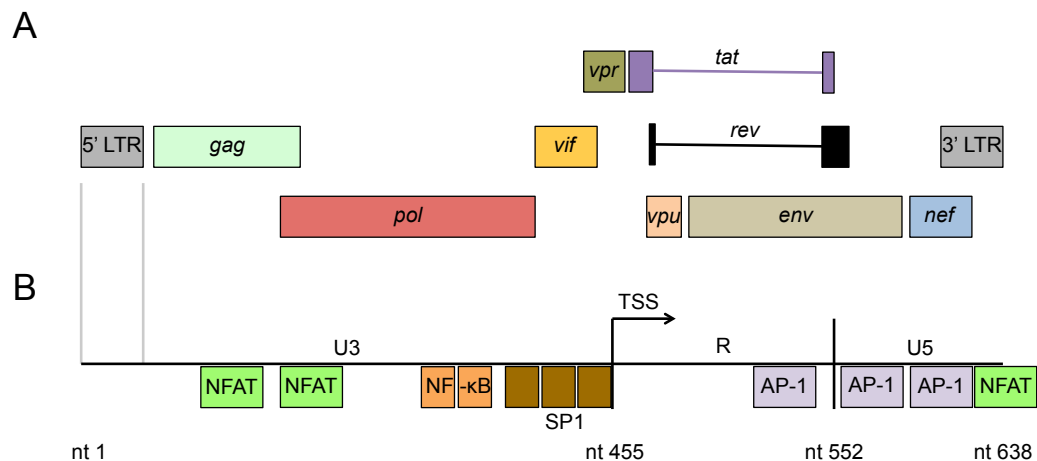
transcription in dendritic cells (Miller *et al.*, 2017). When the HIV-1 envelope binds to its appropriate receptors, it triggers fusion with the cell membrane (Maddon *et al.*, 1988). Fusion is thought to occur through a suggested series of intermediate steps, in which the outer glycoprotein trimer, referred to as gp120, engages with CD4. This allows the coreceptor binding site to become accessible; the HIV-1 fusion peptide then can interact with the target cell, forming a hairpin which pulls apart the cell membrane and facilitating the delivery of the virion (Chan and Kim, 1998; Wang H *et al.*, 2016).

Upon entry, HIV-1 unloads its capsid into the cell cytoplasm. Within the capsid, the RNA genome is reverse-transcribed into complementary DNA. Although the exact timing of reverse transcription has not yet been elucidated, it is believed that reverse transcription is completed by the time of nuclear entry (Rankovic *et al.*, 2017). Reverse transcription and capsid disruption is tightly correlated as revealed by a recent study by the Rouso lab at Ben-Gurion University using time-lapse atomic force microscopy to reveal that pressure inside the capsid increases due to the presence of newly formed DNA, eventually leading to capsid dissociation. After interaction with the nuclear pore complex, the capsid dissociates and the new cDNA is integrated into the host genome by the viral protein IN or integrase. HIV-1 is preferentially integrated into introns of actively transcribed genes (Han *et al.*, 2004), most of which would be located in euchromatic regions near the nuclear pore (Marini *et al.*, 2015; Acuthan *et al.*, 2018). The integration site is one of several key factors that determine whether HIV-1 is transcribed. At this point, HIV-1 expression is regulated not only by its transactivator Tat but also by the

general cellular factors that control gene transcription. This dependency on the host cell will be critical to the experiments I outline in this dissertation.

Once integrated, the viral genome is referred to as a provirus. This provirus is transcribed by the host RNA Polymerase II (RNAPII) for the purpose of making new viral RNA or transcribed and translated for the purpose of making new viral proteins. HIV-1 transcription is regulated by the binding of specific host factors to the 5' Long Terminal Repeat (LTR). The provirus is flanked on either end by an identical LTR that acts as the HIV-1 promoter (Patarca *et al.*, 1987). The presence of both LTRs is directly responsible for the capacity of reverse transcriptase to copy the entire genome including both the 5' and 3' untranslated regions. A number of transcription factors are known to bind to the HIV-1 LTR (and downstream sites) including NF- $\kappa$ B, AP-1, SP1, and NFAT (Calman *et al.*, 1988; Franza *et al.*, 1988; Garcia *et al.*, 1987; Lu *et al.*, 1991). The binding sites of these transcription factors, as well as the structure of the entire provirus, are shown in Figure 1.1. During the early stages of transcription, the HIV-1 transactivator Tat binds to a specific stem-loop structure in the nascent RNA referred to as the TAR region (Hauber and Cullen, 1988). During this process, Tat recruits the host factor P-TEFb or Positive Transcription Elongation Factor, which hyperphosphorylates the C-terminal domain of RNAPII. Phosphorylation results in transcriptional elongation and successful polymerase processivity (Napolitano *et al.*, 2000; Barboric *et al.*, 2001). P-TEFb cycles between an active state that is free to phosphorylate RNAPII and an inactive state in which it is sequestered by the 7SK RNA complex (Yang *et al.*, 2001). While the cellular signals that permit disassembly of the 7SK RNA – P-TEFb complex are not fully

elucidated, it has been shown that UV damage or MAPK signaling as a result of TCR engagement can activate P-TEFb (Yang *et al.*, 2001; Kim *et al.*, 2011). Therefore, successful HIV-1 transcription is regulated by both Tat fluctuations and P-TEFb activity (Weinberger *et al.*, 2005). In addition, the use of dual-fluorescence viruses that contain both inducible and constitutive reporters has indicated a more general role for cellular activation on productive infection (Duverger *et al.*, 2009; Chavez, Calvanese and Verdin, 2015). Cells with high basal levels of NF- $\kappa$ B are biased towards viral replication and away from transcriptional repression (Dahabieh *et al.*, 2014).



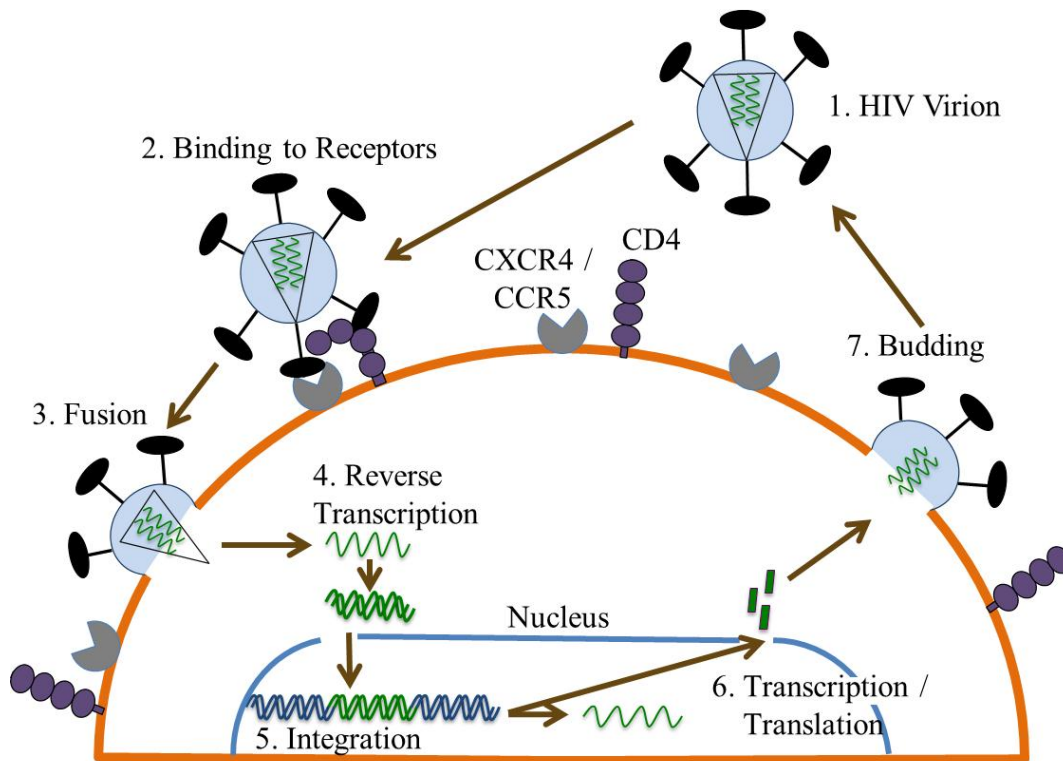
**Figure 1.1: Binding sites of a select number of key transcription factors to the HIV-1 LTR.** (A) HIV-1 proviral genome including both the 5' and 3' LTR's. (B) Detailed diagram of 5' LTR including binding sites of a select number of key transcription factors, transcriptional start site (referred to as TSS), and locations of U3, R, and U5 regions. This figure adapted from (Colin and Van Lint, 2009).

An additional block to HIV-1 replication occurs at the level of splicing. Because HIV-1 encodes its genome as a polycistronic RNA, efficient splicing is required for full expression of all viral products (Purcell and Martin, 1993; Emery *et al.*, 2017). The first

RNAs to emerge from the nucleus are fully spliced and contain the transcripts for HIV-1 Rev and HIV-1 Tat. This is followed by partially spliced transcripts that encode for the accessory proteins and the viral envelope. Finally, unspliced RNA enters the cytoplasm, resulting in both new copies of the viral genome along with the HIV-1 Gag and Pol polyproteins (Stoltzfus, 2009). Because only fully spliced transcripts are exported through normal cellular mechanisms, both the partially spliced and unspliced RNAs require the HIV-specific Rev-dependent export pathway (Fischer *et al.*, 1995).

While a subset of the unspliced RNA remains untranslated as viral RNA, the remaining transcripts must be translated by the cellular ribosome. Together, the viral capsid, various accessory factors, and the newly synthesized genomic RNA converge at the cellular membrane, where they bud to form a new virion (Sundquist and Kräusslich, 2012). The assembly at the lipid surface requires binding between PtdIns(4,5)P<sub>2</sub> and the matrix peptide of the Gag polyprotein (Saad *et al.*, 2006). The virion then co-opts the cellular ESCRT pathway due to indirect interactions between ESCRT factors and the HIV-1 p6 region of Gag to mediate scission from the cellular membrane (Sette *et al.*, 2016). In doing so, the virus acquires its outer lipid leaflet from the host cell. Further maturation by HIV-1 protease results in production of various Gag and Pol proteins, including, but not limited to, matrix (MA), capsid (CA), nucleocapsid (NC), reverse transcriptase (RT), integrase (IN), and protease (PR) (Swanstrom and Wills, 1997). Further rearrangements due to binding between these various proteins and movements of capsid into a conical structure results in the formation of a newly infectious particle,

capable of undergoing additional rounds of infection (Frank *et al.*, 2015). A depiction of the life cycle of HIV-1 is shown (Figure 1.2).



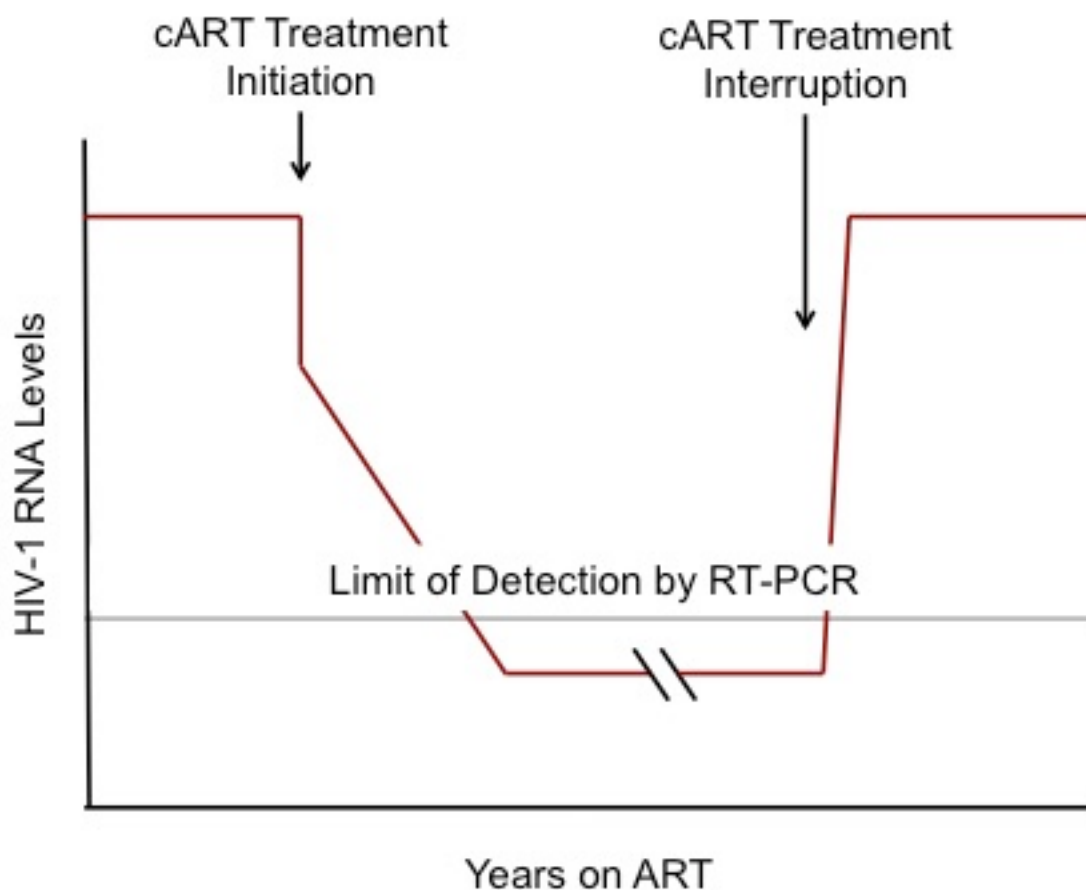
**Figure 1.2: Life cycle of HIV-1.** Major steps of the HIV-1 life cycle are shown, with emphasis placed on the stages where the virus is under the control of host cell machinery, including transcription / translation.

## HIV-1 Latency

### *Biology and Model Systems*

When the development of cART resulted in the suppression of viremia below the limit of detection, it was thought that a complete absence of viral replication would allow the host immune system to eradicate HIV-1 since infected cells will eventually undergo apoptosis due to either the cytopathic effects of the virus or clearance by NK cells and

CD8+ T cells (Koup *et al.*, 1994; Petravic *et al.*, 2014). If these infected cells were simultaneously blocked from producing new infectious particles, then a short course of ART would theoretically be sufficient to eliminate HIV-1 infection. However, in the years following the widespread use of ART, not one patient has achieved a cure through this mechanism (Chun *et al.*, 1997). In fact, after decades of antiretroviral treatments, even a short interruption of medication results in a predictable rebound of viremia as depicted in Figure 1.3 (Van Lint, Bouchat and Marcello, 2013). This is due primarily to the persistence of silent proviruses in long-lived memory CD4+ T cells.



**Figure 1.3: HIV-1 rebounds after cART interruption.** Depiction of patient viral RNA levels as measured by RT-PCR both before and after antiretroviral therapy. Figure based on (Van lint, Bouchat and Marcello, 2013).

As a component of the adaptive immune system, CD4<sup>+</sup> T cells and their progeny clones survive long-term and form the basis of immunological memory (Rogers, Dubey and Swain, 2000; Boyman *et al.*, 2009). If HIV-1 is integrated into these cells and if these cells do not produce any viral products that could be recognized by the immune system, the virus can evade detection. This phenomenon, known as HIV latency, forms the primary barrier to a cure for HIV-1. Like any normal cellular gene, HIV-1 can be either expressed or repressed. This repression thus prevents viral spread but also shields infected cells from antiviral immunity (Finzi *et al.*, 1997). The HIV-1 latent reservoir is also maintained by clonal proliferation of latently infected cells, which has been shown to allow for cellular duplication without viral re-expression (Wang *et al.*, 2018).

Our understanding of the mechanisms which maintain HIV-1 in a latent state derive from a number of *in vitro* models of HIV-1 latency as well as analysis of cells removed *ex vivo* from patients on ART. Among patients with full viral suppression, latent provirus has been discovered primarily in resting memory CD4<sup>+</sup> T cells. These include both transitional memory and central memory subsets (Chomont *et al.*, 2009). PCR analysis has confirmed that roughly 1 in 1000 target resting cells are latently infected, but it is estimated that only 1 in 1,000,000 target cells contain an inducible latent provirus that can easily be re-activated as measured by the viral outgrowth assay or VOA (Ho *et al.*, 2013). To perform the VOA, researchers remove peripheral blood mononuclear cells (PBMCs) and culture them in limiting dilution along with target cells for HIV-1. The PBMCs are then reactivated with phytohaemagglutinin or PHA, which although highly

toxic, is a gold standard for latency reactivation *in vitro*. HIV-1 expression is then measured by p24 ELISA (Siliciano and Siliciano, 2005).

Although latent HIV-1 has been isolated primarily in CD4<sup>+</sup> T cells and is most widely studied within this population, it is important to note that this is not the only cellular reservoir for latent provirus. Gammadelta or  $\gamma\delta$  T cells have been described as a target for HIV-1 infection and a source of rebounding virus following treatment interruption.  $\gamma\delta$  T cells have an important role in modulating the immune system and assisting other cell types, especially at barrier sites including the skin and mucosa (Paul *et al.*, 2014). Although less than 10% of  $\gamma\delta$  T cells are CD4<sup>+</sup> *in vivo*, HIV-1 still requires the expression of CD4 in order to bind (Imlach *et al.*, 2003). HIV-1 can be isolated from  $\gamma\delta$  T cells in patients infected with HIV-1 on ART (Soriano-Sarabia *et al.*, 2015). Therefore, more information is needed regarding the potential contribution of  $\gamma\delta$  T cells to HIV-1 persistence.

Macrophages can also be infected by HIV-1 (Koenig *et al.*, 1986) and form a viral reservoir during prolonged ART. This has been identified both in humanized mouse models and in SIV-infected primates (Honeycutt *et al.*, 2017; Avalos *et al.*, 2017). Microglia, in particular, may contribute to HIV-1 persistence (Llewellyn *et al.*, 2018). However, when humanized myeloid only mice (containing human myeloid cells and human B cells) were infected with HIV-1 and given ART 5 weeks later, just 1/3 of all mice harbored latent virus (Honeycutt *et al.*, 2017). The fact that the majority of mice were not latently infected is supportive of the fact that CD4<sup>+</sup> T cells, and not macrophages, are the primary reservoir for latency.

Because CD4<sup>+</sup> T cells are the primary source for rebounding virus, most model systems that reproduce HIV-1 latency in a laboratory environment use primary CD4<sup>+</sup> T cells or CD4<sup>+</sup> T cell lines (Table 1.1). The first attempts to model HIV-1 latency were performed in A3.01 (Folks *et al.*, 1989) and Jurkat cells (Jordan, Bisgrove and Verdin, 2003) by the Fauci and Verdin laboratories. Cells with integrated virus but no clear RNA or protein production were isolated after multiple rounds of flow cytometry or reverse transcriptase activity assays. While these cells are useful for comparisons of various latency reversing agents (LRAs), they fail to adequately incorporate all of the mechanisms that contribute to HIV-1 latency *in vivo*. For instance, the A3.01 cell model, which resulted in creation of the ACH-2 line, has a defective TAR element that accounts for its propensity for latency (Emiliani *et al.*, 1996).

Other models use primary cells and attempt to either artificially prolong cell survival or infect specific types of cells known to harbor latent proviruses. The Siliciano model, for instance, uses the cell survival factor Bcl-2 to prevent cellular apoptosis (Kim *et al.*, 2014), while the O'Doherty / Greene model uses the slight perturbation caused by spinoculation to enhance viral integration into resting cells (Swiggard *et al.*, 2005; Lassen *et al.*, 2012). The Lewin model requires chemokine signaling (Saleh *et al.*, 2007), while the Planelles model directly infects certain subsets of memory cells (Bosque and Planelles, 2009).

Commonly Used Models of HIV-1 Latency			
Model	Parental Cell	Mechanism to Enrich for Latency	References
<b>ACH-2 (Fauci)</b>	A3.01	Defective TAR Element	Folks <i>et al.</i> , 1989 Emiliani <i>et al.</i> , 1996
<b>J-Lat (Verdin)</b>	Jurkat	Multiple Rounds of Cell Sorting to Isolate TNF $\alpha$ – Sensitive Silent Proviruses	Jordan, Bisgrove and Verdin, 2003
<b>O’Doherty / Greene</b>	Primary CD4+	Spinoculation	Swiggard <i>et al.</i> , 2005 Lassen <i>et al.</i> , 2012
<b>Lewin</b>	Primary CD4+	Chemokine Signaling (CCL19 and CCL21)	Saleh <i>et al.</i> , 2007
<b>Planelles</b>	Primary CD4+	Enrichment of Central Memory Cells / Polarization Towards Th1 and Th2	Bosque and Planelles, 2009
<b>Siliciano</b>	Primary CD4+	Transduction of Bcl-2	Kim <i>et al.</i> , 2014

**Table 1.1: Commonly used models of HIV-1 latency.** Models are listed along with methods for enrichment of latently infected cells.

Using these models to gain insights into the transcriptional regulation of HIV-1, a model has emerged in which multiple mechanisms regulate viral expression including epigenetic regulation, recruitment of key transcription factors, and RNAPII pausing. A primary determinant of viral reactivation in latently infected cells is a positioned nucleosome just downstream from the HIV-1 transcriptional start site, known as nuc-1 (Verdin, Paras and Van Lint, 1993). This nucleosome appears to be remodeled during transcriptional elongation (Van Lint *et al.*, 1996). The chromatin structure is opened through the addition of acetyl groups by HATs or histone acetyltransferases, many of which are recruited by transcription factors that are induced upon T cell signaling and bind the HIV-1 LTR, including NF- $\kappa$ B and AP-1 (Thierry *et al.*, 2004). In contrast, the

association of histone deacetylases or HDACs with HIV-1 inhibits transcription (Williams *et al.*, 2006). In addition, the chromatin remodeling complex SWI/SNF can directly remodel *nuc-1*, creating a transcriptional block or allowing for polymerase processivity (Mahmoudi *et al.*, 2006; Rafati *et al.*, 2011). These alternative roles are still being explored, but evidence exists that the binding to *nuc-1* of specific variants of SWI/SNF, referred to as BAF and PBAF, are responsible.

Latency is associated with a lack of histone acetylation (He and Margolis, 2002) and premature polymerase pausing. This pausing has been identified in both the Henderson and Karn laboratories to be associated with the presence of the host repressive factors Negative Elongation Factor (NELF) and DRB Sensitivity Inducing Factor (DSIF) with RNAPII (Zhang, Klatt, Gilmour and Henderson, 2007; Jadowsky *et al.*, 2014). These proteins prohibit RNAPII from proceeding downstream and ultimately recruit a third factor, Pcf11, which is known to cleave the nascent RNA, repressing HIV-1 transcription (Zhang, Klatt, Henderson and Gilmour, 2007). NELF and DSIF are both regulated by P-TEFb, which modulates their interactions with RNAPII through phosphorylation (Ping and Rana, 2001; Fujinaga *et al.*, 2004). Phosphorylated NELF can no longer bind the polymerase, while phosphorylated DSIF transitions into an activating factor that proceeds downstream with RNAPII. The HIV-1 protein Tat plays a key role in this process due to its ability to recruit P-TEFb to RNAPII once it is bound to the HIV-1 TAR region (Ping and Rana, 2001).

Each cell model system of latent HIV-1 has its advantage, although they often recapitulate only specific features of the entire latent reservoir. They exaggerate different

mechanisms that contribute to latency in order to create a large population of latently infected cells. These models are not optimal for understanding how latency is established at the time of HIV-1 infection. In particular, we do not know what signals are required for productive infection or the establishment of the reservoir. However, these cell models have been useful tools for identifying and exploring possible LRAs.

### *“Shock and Kill”*

Based on the limited knowledge of the mechanisms that maintain latent HIV-1, several researchers proposed the use of LRAs to eradicate the viral reservoir. These LRAs were designed to prevent deacetylation of nuc-1 or to enhance release of P-TEFb, promoting HIV-1 expression; this would allow infected cells to be recognized and cleared by the immune system. Even if full reactivation of every integrated provirus was not achieved, a functional cure was originally thought to be possible through this process, known as “shock and kill” (Hamer, 2004).

Initial LRAs were histone deacetylase inhibitors or HDACi's, including valproic acid, which prevent the removal of acetyl groups from open and accessible nucleosomes. Valproic acid was already in use as an epilepsy therapeutic and was fast-tracked for HIV-1 clinical trials (Ylisastigui *et al.*, 2004). One clinical trial indicated that valproic acid was capable of inducing a 75% reduction in the amount of inducible latent proviruses by the VOA (Lehrman *et al.*, 2005). In spite of promising early results using valproic acid, there is now contradictory evidence regarding whether valproic acid can actually reduce

the number of inducible latent proviruses, and no clinical trial has shown an effect on the size of the entire DNA viral load (Archin *et al.*, 2008; Sagot-Lerolle *et al.*, 2008; Archin *et al.*, 2010; Routy *et al.*, 2012).

Other HDACi's under consideration include SAHA or its analog SBHA. While SAHA can reactivate latent HIV-1 in HIV-infected cell lines such as J-LATs (based on Jurkat cells) and even has been shown to induce HIV-1 RNA expression in *ex vivo* PBMCs (Contreras *et al.*, 2009; Reuse *et al.*, 2009; Archin *et al.*, 2009; Barton *et al.*, 2016), it has failed to reduce the amount of total HIV-1 DNA in clinical trials (Elliott *et al.*, 2014; Barton *et al.*, 2016). Other studies have failed to detect any significant increases in the amount of HIV-1 RNA expression within *ex vivo* patient samples after stimulation with either valproic acid or SAHA (Blazkova *et al.*, 2012). As a result of these conflicting studies, the use of HDAC inhibitors as single latency reversing agents is no longer central to the “shock and kill” strategy of HIV-1 eradication.

Other LRAs being explored are known to target different mechanisms that maintain latent HIV-1. These include histone methyltransferase inhibitors (Bernhard *et al.*, 2011; Bouchat *et al.*, 2012; Friedman *et al.*, 2011; Boehm *et al.*, 2017), DNA methyltransferase inhibitors (Kauder *et al.*, 2009; Blazkova *et al.*, 2009; Friedman *et al.*, 2011), and protein kinase C activators. PKC agonists, in particular, have shown synergy with other LRAs, indicating that multiple pathways may have to be engaged in order to achieve a clinically relevant level of latency reversal (Bartholomeeusen *et al.*, 2013; Dar *et al.*, 2014).

In addition, JQ1 is being explored as a potential LRA (Banerjee *et al.*, 2012; Bartholomeeusen *et al.*, 2012; Zhu *et al.*, 2012). It is hypothesized that JQ1, a BET bromodomain inhibitor, functions by targeting BRD4, which is known to bind P-TEFb (Bisgrove *et al.*, 2007; Bartholomeeusen *et al.*, 2012; Li *et al.*, 2013). Bartholomeeusen *et al.* showed that addition of JQ1 resulted in a release of P-TEFb from the 7SK complex, resulting in HIV-1 transcriptional elongation. Melanie Ott's lab has indicated that a BRD4 variant, BRD4S, may directly inhibit HIV-1 expression by associating with the nucleosome remodeling complex SWI/SNF (Conrad *et al.*, 2017), providing further evidence that JQ1's regulation of HIV-1 transcription is due to its ability to bind BRD4. However, it should be noted that the effects of JQ1 have so far been limited to *in vitro* analysis, and there are serious concerns regarding toxicity of several of the compounds listed here, particularly PKC agonists. In spite of promising data using cell lines, no LRA has successfully led to substantial clearance of the latent reservoir in a patient as measured by PCR.

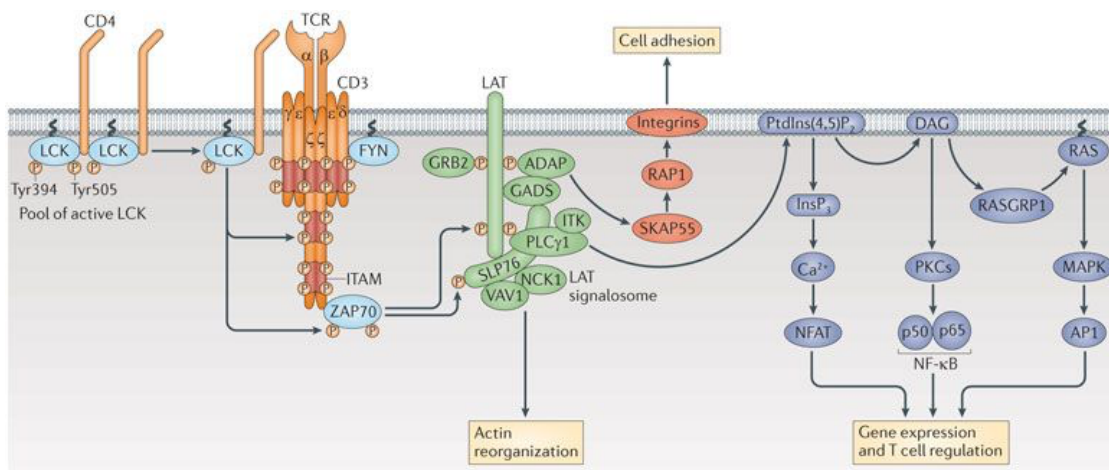
#### *Establishment of Latent HIV-1 and the Role of T Cell Signaling*

While the concentration of Tat (Donahue *et al.*, 2012; Razoosky *et al.*, 2015) and the chromatin accessibility within an infected cell are understood as critical to productive transcription and infection (Miller-Jensen *et al.*, 2012), the availability of host factors, proteins that regulate RNAPII, and transcriptional mechanisms are not fully appreciated. It is known that T cell activation is needed for both the activation of host factors

necessary for HIV-1 transcription (Acuto and Michel, 2003; Huang and Wange, 2004) as well as efficient viral integration. Therefore, T cell activation appears to be required for productive infection (Stevenson *et al.*, 1990; Oswald-Richter *et al.*, 2004). Indeed, signals from the TCR/CD3 complex and coreceptor CD28 substantially upregulate HIV-1 expression (Gruters *et al.*, 1991; Natarajan, August and Henderson, 2010). The HIV-1 protein Nef may co-opt this mechanism by amplifying TCR signaling (Fenard *et al.*, 2005; Neri *et al.*, 2011).

TCR signaling occurs through engagement of a T cell with its cognate antigen presented in the context of MHC Class I or II from the same genetic background (Dembic *et al.*, 1986; von Boehmer and Kisielow, 1990). CD4<sup>+</sup> T cells require presentation from a Class II molecule, which are found on professional APCs (Wang and Reinherz, 2002). This engagement results in clustering of the TCR/CD3 complexes and CD28 proteins (Ohnishi *et al.*, 1995; Lillemeier *et al.*, 2010). When brought into proximity with one another, associated Src kinases, including Lck, phosphorylate both the critical Immunoreceptor Tyrosine-Based Activation Motifs or ITAMs contained within the CD3 protein as well as tyrosine residues within the cytoplasmic tail of CD28 (Gibson *et al.*, 1996; Rossy *et al.*, 2013). These phosphorylated residues then act as binding sites for the Syk-kinase, Zap70. In turn, Zap70 is phosphorylated and becomes a key component within a newly assembled network of proteins, such as LAT and the SH2-domain containing kinases (Neumeister *et al.*, 1995; Lo *et al.*, 2018). A proximal signaling complex is orchestrated around LAT (Figure 1.4), resulting in downstream actin rearrangements (Bunnell *et al.*, 2001). In addition, the SH2-containing enzyme PLC $\gamma$ 1 is

recruited to the plasma membrane, where it cleaves  $\text{PtdIns}(4,5)\text{P}_2$  (Rhee, 2001). As a result, multiple arms of the T cell receptor pathway are engaged, resulting in calcium release (Bilal *et al.*, 2015), MAP Kinase signaling (Frearson and Alexander, 1998), and NF- $\kappa$ B activation downstream of Protein Kinase C (PKC) (Zhao *et al.*, 2014). Activation of these multiple cascades increases transcription for a number of host genes and differentiation-determining factors (Smith-Garvin, Koretzky and Jordan, 2009; Adair *et al.*, 2016).



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**Figure 1.4: T cell receptor signaling results in activation of multiple pathways.** TCR signaling leads to phosphorylation of critical tyrosine residues within ITAMs that enable the formation of a proximal signaling complex. Creation of this complex results in actin reorganization and stimulation of transcription factors downstream of  $\text{PtdIns}(4,5)\text{P}_2$ . Recreated here with permission, in its entirety from (Brownlie and Zamoyska, 2013). Figure caption is the original work of the author of this dissertation.

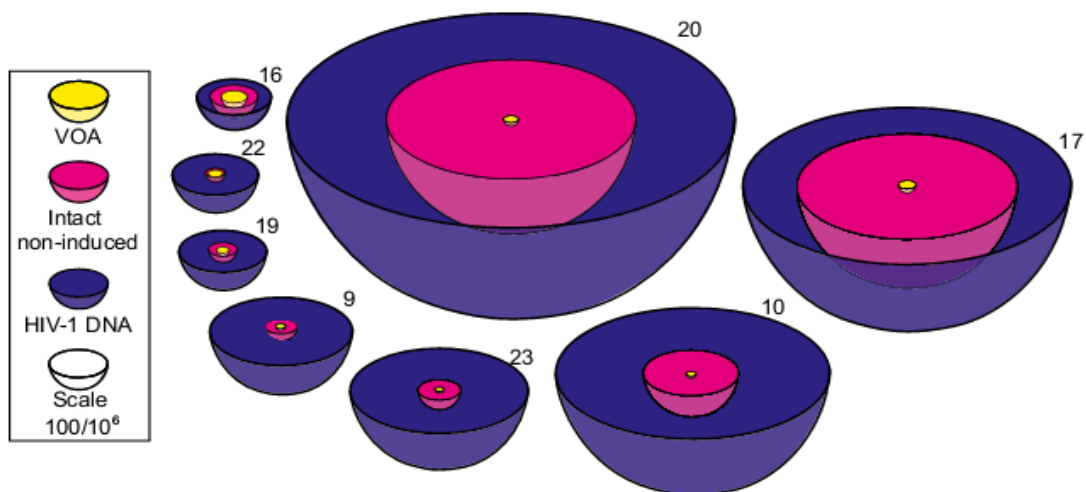
In addition to roles upstream of gene transcription, T cell signaling impacts cell maturation (Brocker, 1997; Pepper and Jenkins, 2011). Naïve T cells which become activated by stimulation through their cognate antigen transition into either effector populations or memory cells. Latently infected cells isolated from patients on ART

predominately express memory phenotypes (Brenchley *et al.*, 2004; Chomont *et al.*, 2009). The Planelles model of HIV-1 latency attempts to recapitulate this by differentiating CD4<sup>+</sup> T cells into central memory cells (Bosque and Planelles, 2009).

Several papers, including those from the Henderson lab, have implicated T cell signaling in the regulation of productive HIV-1 replication (Natarajan, August and Henderson, 2010; Schiralli Lester *et al.*, 2013). For example, studies have suggested that different antigen-presenting cell subsets alter HIV-1 replication by differentially activating T cells (Kumar *et al.*, 2015). Furthermore, it has been shown that cells with low levels of activated NF- $\kappa$ B and decreased expression of activation markers may be biased towards harboring latent infections (Duverger *et al.*, 2009; Dahabieh *et al.*, 2014; Chavez, Calvanese and Verdin, 2015). Signals that predispose cells towards an anergic phenotype have also been linked to repression of HIV-1 (Seu *et al.*, 2015). However, these experiments fail to describe the actual signaling cascades that account for this correlation, and direct evidence is still needed that minimal TCR signaling during infection predisposes HIV-1 towards latency.

Understanding the establishment of latent HIV-1 is also essential since it has been shown that there are wide differences between the capacities to reactivate latent reservoirs from different patients. It was originally assumed that the majority of non-inducible proviruses were defective, most likely due to errors with reverse transcription. However, the Siliciano lab demonstrated that a portion of the non-inducible DNA reservoir is fully competent based on sequencing analysis, which is shown in Figure 1.5 (Ho *et al.*, 2013; Hosmane *et al.*, 2017). Our lack of knowledge regarding the exact

mechanisms which account for these various sub-populations of latently infected cells, some of which are refractory to the strongest LRAs identified so far, highlights the importance of understanding the role of the cellular environment at the time of infection on viral fate. A primary goal of my work was to understand the signaling requirements for HIV-1 infection and whether the input of signals at the time of infection shaped the size of the inducible latent reservoir.



**Figure 1.5: A significant portion of the latent reservoir consists of non-inducible fully competent proviruses.** Depiction of the DNA reservoir from various patients on antiretroviral therapy. The size of the eggshell is an indication of the number of proviruses. The yellow sphere represents the size of the latent reservoir as measured by the viral outgrowth assay. The magenta sphere represents the size of the latent reservoir as measured by sequencing. The blue sphere represents the total DNA load. Recreated here with permission, in its entirety from (Ho *et al.*, 2013). Figure caption is the original work of the author of this dissertation.

### “Block and Lock”

With the future of “shock and kill” approaches to eradication of latent HIV-1 in doubt, increasing interest has focused on the formation of the latent reservoir. If we can

determine why some cells enable productive infections while others harbor latent proviruses, perhaps we can manipulate the balance between these two populations. In fact, a growing body of research has focused on a converse strategy to “shock and kill,” referred to as “block and lock.” This repressive approach imagines a permanent suppressive environment for the integrated provirus, allowing a patient to cease therapy indefinitely with only periodic clinical sampling to ensure a lack of viral replication (Méndez *et al.*, 2018; Debyser *et al.*, 2018). For example, the Valente lab has focused on Tat inhibition through the preferential binding of didehydro-Cortistatin A. This prevents engagement between the TAR region and the HIV-1 transactivator (Mousseau *et al.*, 2012; Mousseau *et al.*, 2015).

The global cellular environment not only affects levels of host transcription factors but also directly alters the local chromatin landscape where the virus has integrated. If we are to achieve a “block and lock” method to repress HIV-1, we will most likely have to modify the epigenome along the provirus. This level of precise gene editing can be achieved through the use of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR).

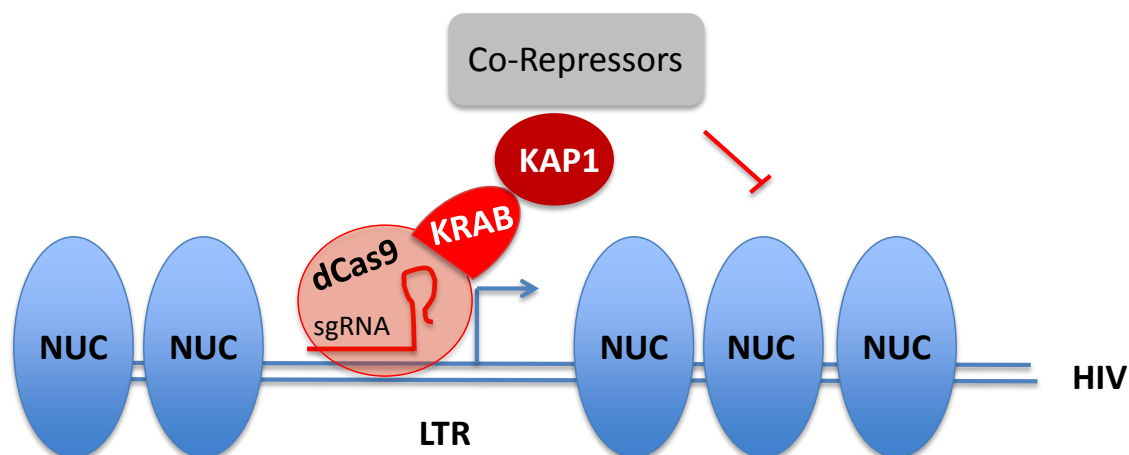
CRISPR associated protein 9 or Cas9 can be isolated from multiple bacterial species including *Streptococcus pyogenes* and *Staphylococcus aureus* (Cho *et al.*, 2013; Ran *et al.*, 2015). It forms an essential part of the CRISPR defense system in bacterial cells. Briefly, CRISPR works by extracting various segments of foreign DNA and inserting it into a CRISPR locus. In nature, this would often be phage DNA. When a bacterial cell is re-infected with DNA belonging to a pathogen that it has encountered

before, the complementary stored sequence will bind to the incoming DNA. This will target Cas9 to the pathogenic DNA, which will then perform its exonuclease activity to destroy the invader (Barrangou *et al.*, 2007; Mali, Esvelt and Church, 2013).

The ease with which this system works has led scientists to substitute complementary sequences to phage DNA with a guide RNA directed against a target gene of choice. In combination with the bacterial exonuclease, gene editing can then be achieved with minimal off-target effects (Kim *et al.*, 2015). A number of labs have shown promising results using CRISPR to excise HIV-1 DNA; however, it is expected that use of CRISPR in vivo will result in viral escape (Wang G *et al.*, 2016; Wang Z *et al.*, 2016). In addition, although CRISPR has relatively few off-target effects, any non-specific gene editing is a serious concern for therapeutic applications (Fu *et al.*, 2013). To prevent this occurrence, I propose using a disabled or nuclease-deficient Cas9 system (dCas9) to target chromatin repressors to HIV-1 DNA instead of an exonuclease.

Nuclease-deficient Cas9 was developed in an attempt to isolate the residues responsible for the exonuclease activity inherent to CRISPR. In order to cut both strands of DNA, Cas9 uses two separate domains, referred to as HNH and RuvC. Mutations in both domains render the Cas9 defective (Jinek *et al.*, 2012). However, dCas9 retains the targeting capabilities of CRISPR and can be used to bring transcription factors directly to a gene of interest (Zhang *et al.*, 2015). There are also attempts to modify dCas9 as an inducible system under the control of a stimulus such as rapamycin (Zetche, Volz and Zhang, 2015; Brocken, Tark-Dame and Dame, 2018).

Other labs have shown the potential for the CRISPR system to induce HIV-1 expression by fusing a nuclease-deficient Cas9 to various transcriptional activators (Zhang *et al.*, 2015; Saayman *et al.*, 2016). I propose the fusing of Cas9 to a Krüppel Associated Box (KRAB) Domain. KRAB domains are known to engage with cellular KRAB-Associated Protein-1 or Kap1 (also known as Trim28), which recruits various transcriptional repressors, resulting in gene silencing and spreading repressive chromatin marks (Friedman *et al.*, 1996; Groner *et al.*, 2010). These repressors are believed to include histone methyltransferases, histone deacetylases, and heterochromatin protein 1 (Groner *et al.*, 2010). KRAB-Kap1 has been identified as a key regulator of endogenous retroviral elements (Rowe *et al.*, 2010) and thus is a good candidate for both repressing HIV-1 and potentially mediating long-term epigenetic silencing of the provirus.



**Illustration 1.1: dCas9-targeted repression of HIV-1.** Nuclease-deficient Cas9 fused to a KRAB domain can be used to recruit cellular factors such as Kap1 to the integrated HIV-1 provirus in order to induce latency and remodel the local chromatin organization into a heterochromative state.

## Specific Aims and Hypothesis

Significant progress has been achieved in the treatment of Human Immunodeficiency Virus. Antiretroviral therapies limit progression to AIDS through a combination of inhibitors. However, ART does not cure HIV-1 infection. If therapy is interrupted, patients experience a viral rebound due to the persistence of an inducible reservoir primarily consisting of latently infected CD4+ T cells. This forces patients to remain on ART indefinitely, but these medications have substantial side effects and do not prevent all pathologies associated with HIV-1. For these reasons, the scientific community has prioritized the search for a cure that will eliminate latent HIV-1, but more insights are needed regarding the establishment of the latent reservoir. In this dissertation, I both investigate the global cellular signals that lead to formation of latent infections and bias an infection towards latency by manipulating the local chromatin environment of the provirus.

Analysis of latently infected cells revealed that the HIV-1 long terminal repeat is associated with repressive transcription factors (Bernhard *et al.*, 2013). These repressors recruit histone deacetylases that modify the first nucleosome downstream of the transcriptional start site into a closed conformation (Williams *et al.*, 2006). As a result, RNAPII pauses prematurely and complete viral transcripts are not produced (Feinberg, Baltimore and Frankel, 1991; Zhang, Klatt, Gilmour and Henderson, 2007; Natarajan *et al.*, 2013). The host immune system then fails to recognize this latent reservoir. While data indicates a role for both integration site (Miller-Jensen *et al.*, 2012; Lelak *et al.*,

2015) and abundance of the HIV-1 transcriptional transactivator Tat in the establishment and maintenance of latency (Donahue *et al.*, 2012; Razooky *et al.*, 2015), recent work suggests that the level of cellular activation at the time of infection is also a key determinant (Duverger *et al.*, 2009; Dahabieh *et al.*, 2014; Chavez, Calvanese and Verdin, 2015). However, these studies have been correlative and direct evidence is still needed. To identify signaling cascades that participate in the establishment of HIV-1 latency, I have designed a tunable and regulated cell model that allows me to modulate T cell receptor signaling at the time of infection. Based on the evidence that increased cellular stimulation results in enhanced HIV-1 replication (Duverger *et al.*, 2009; Dahabieh *et al.*, 2014), I hypothesized that the global cellular environment at the time of HIV-1 infection determines the potential for inducible latent infection and that this axis can be bypassed by modification of the local chromatin environment. Accordingly, I addressed the following aims:

**Specific Aim 1: Determine the effect of distinct T cell receptor signal strengths at the time of HIV-1 infection on viral expression within primary cells and reactivation of latent proviruses.** I used a novel primary cell system to manipulate TCR signaling at the time of infection and examine the signaling requirements for efficient HIV-1 expression. To mimic TCR signaling, I transduced CD4<sup>+</sup> T cells with chimeric antigen receptors that contain both the intracellular signaling domains of CD3 $\zeta$  and CD28 along with one of several extracellular Her2 binding domains with different affinities for Her2. I used flow cytometry to confirm CAR expression, *Alu*-PCR to determine HIV-1 integration, and both RT-PCR and luciferase analysis to measure HIV-1 transcription.

With this system, I verified my hypothesis that increased T cell signaling enhances HIV-1 transcription. I also infected primary T cells and stimulated them through either the low or high affinity CAR. I then restimulated sorted non-HIV expressing cells with latency-reversing agents to measure reactivation. These experiments revealed that differential signaling at the time of infection resulted in the formation of subsets of latently infected cells with varying capacities for proviral induction.

**Specific Aim 2: Analyze transcriptional landscape of the provirus among cells receiving differential stimulation at the time of HIV-1 infection.** I hypothesized that cells with minimal stimulation at the time of infection display a bias for the presence of host repressors and a lack of polymerase processivity. To test this, I used chromatin immunoprecipitation to examine RNAPII processivity and the recruitment of host regulators to the transcriptional start site. I also analyzed markers of chromatin accessibility such as histone acetylation. These studies identified downstream targets of TCR-associated signals that repress HIV-1 during acute infection.

**Specific Aim 3: Use a nuclease-deficient Cas9 construct to recruit host repressors to the provirus and suppress HIV-1 expression.** To determine if an infection can be biased towards latency after HIV-1 integration I used a nuclease-deficient Cas9 fused to a Krüppel associated box domain in order to recruit the repressor Kap1 to the provirus. HEK293T cells were infected with single-round HIV-Luciferase and transfected with a dCas9-KRAB construct. One day later, infected cells were transfected with HIV-1 specific guide RNAs to repress viral transcription. HIV-1 expression was measured by luciferase analysis. I also electroporated latently infected

Jurkat cells with the nuclease-deficient Cas9 and HIV-specific guide RNAs to block latency reactivation as measured by RT-PCR. I verified my hypothesis that transfection with dCas9-KRAB represses HIV-1 RNA and protein expression.

My findings elucidated how TCR signaling regulates HIV-1 transcription and latency. These experiments may inform both why such a large portion of the latent reservoir is non-reactivable as well as the efficacy of block and lock strategies, whether there are new druggable targets that can bias an infection towards or away from latency.

## CHAPTER TWO: MATERIALS AND METHODS

Parts of this chapter were originally published in: Gagne M, Michaels D, Schiralli Lester G, Wong W, Gummuluru S, Henderson AJ. Strength of T Cell Signaling Regulates HIV-1 Replication and Establishment of Latency. *bioRxiv*. <https://doi.org/10.1101/432401>.

### Cells

Jurkat CD4<sup>+</sup> T cells (E6-1) and human embryonic kidney 293T (HEK293T) cells were obtained from American Type Culture Collection (ATCC). Jurkat cells were cultured in RPMI 1640, 5% FBS (Corning, Inc.), 100 <sup>units</sup>/<sub>mL</sub> penicillin (Invitrogen), 100 <sup>µg</sup>/<sub>mL</sub> streptomycin (Invitrogen), and 2mM L-glutamine (Invitrogen). HEK293T cells were cultured in Dulbecco's Modified Eagle Medium, 10% FBS, 100 <sup>units</sup>/<sub>mL</sub> penicillin, 100 <sup>µg</sup>/<sub>mL</sub> streptomycin, and 2mM L-glutamine. Cells were grown at 37° C with 5% CO<sub>2</sub>.

Primary CD4<sup>+</sup> T cells were derived from de-identified healthy blood leukapheresis packs purchased from NY Biologic. Mononuclear cells were enriched from leukopacks by centrifugation through Histopaque gradient (Sigma-Aldrich). CD4<sup>+</sup> T cells were isolated by negative selection using EasySep Human CD4<sup>+</sup> T Cell Enrichment Kits from StemCell Technologies. CD4<sup>+</sup> cells were maintained in RPMI 1640, 10% FBS, 100 <sup>units</sup>/<sub>mL</sub> penicillin, 100 <sup>µg</sup>/<sub>mL</sub> streptomycin, and 2mM L-glutamine at 37° C with 5% CO<sub>2</sub>. Prior to transduction with CARs, primary cells were supplemented with 10 <sup>units</sup>/<sub>mL</sub> IL-2 and 10 <sup>ng</sup>/<sub>mL</sub> IL-7. Following transduction, IL-2 was removed from most culture conditions.

J-Lat cells (6.3) were obtained from NIH AIDS Reagent Program and were cultured in RPMI 1640, 10% FBS, 100 <sup>units</sup>/<sub>mL</sub> penicillin, 100 <sup>µg</sup>/<sub>mL</sub> streptomycin, and 2mM L-glutamine. Cells were grown at 37° C with 5% CO<sub>2</sub>. Following transduction with dCas9, J-Lat cells were cultured with 10 <sup>µg</sup>/<sub>mL</sub> Blasticidin as a selection marker. Blasticidin was removed from media 2 days prior to electroporation. All cells and cell lines were split every 2-3 days.

### **sgRNA Screen**

dsaCas9 sgRNAs were designed using the online program Benchling (Benchling, 2019) by searching the NL4-3 sequence for 23-base pair long binding sites that contained the required PAM sequence of 5'-(N)NGRRT-3'. All chosen sites (see Table 2.1) had an efficiency score of > 50% and a specificity score of > 75%. dsaCas9 sgRNAs were expressed under the control of a SFFV promoter and were fused to the required tracrRNA sequence within the lentiviral vector pHR. In addition, blank dsaCas9 sgRNAs were obtained that contained only the tracrRNA component. All dsaCas9 sgRNA plasmids were constructed in the Wilson Wong laboratory at the BU School of Biomedical Engineering.

dspCas9 sgRNAs were chosen based on a literature search (see Table 2.1), with sg361 modified from “sg362F T” (in Saayman *et al.*, 2016) in order to not exceed the required 20 base pairs for dspCas9. sg397 was obtained from “Protospacer D” in Hu *et al.*, 2014. Both sequences were purchased from IDT as Alt-R CRISPR-Cas9 crRNAs and

fused to the required sequence (GUUUUAGAGCUAUGCU) necessary to bind to the Alt-R CRISPR-Cas9 tracrRNA. Annealing of the two strands of RNA occurred as follows: 1  $\mu$ L of 100  $\mu$ M crRNA and 1  $\mu$ L of 100  $\mu$ M tracrRNA were mixed in 98  $\mu$ L Nuclease-Free Duplex Buffer (IDT) at 95°C for 5 m. Annealed solutions were stored at -20°C. In addition, Scramble sgRNAs were obtained from IDT that bound to no known region of the human genome (Alt-R CRISPR-Cas9 Negative Control crRNA #1, 1072544).

<b>crRNA Sequences</b>		
sgRNA	sgRNA format	Sequence
dsa397	Plasmid DNA	5'- GGTGTGGCCTGGGCGGGACTG - 3'
dsa518	Plasmid DNA	5'- AGCTTTATTGAGGCTTAAGCA - 3'
dsa705	Plasmid DNA	5'- TGCCGTGCGCGCTTCAGCAAG - 3'
dsa818	Plasmid DNA	5'- GAGCGTCAGTATTAAGCGGGG - 3'
dsa2285	Plasmid DNA	5'- CCCCTATCTTTACTTTGACG - 3'
dsa2839	Plasmid DNA	5'- AATTAGGAATACCACATCCCG - 3'
dsa5876	Plasmid DNA	5'- AAGCAGTTTTAGGCTGACTTC - 3'
dsp361	RNA	5'- CUACAAGGGACUUUCCGCUG - 3'
dsp397	RNA	5'- GUGUGGCCUGGGCGGGACUG - 3'

**Table 2.1: Sequences used for crRNA screen.** dsaCas9 sgRNAs and dspCas9 sgRNA sequences are listed.

## Viruses, Transfections, and Transductions

CARs were driven by a SFFV promoter in the lentiviral vector pHR (Schier *et al.*, 1996; Chmielewski *et al.*, 2004). pNL4-3.Luc.R-E- was obtained from NIH AIDS Reagent Program. BRU- $\Delta$ Env-GFP was a gift from Dr. Gregory Viglianti (Boston University). CAR lentiviruses were made by transfection of lentiviral expression vectors, VSV-G env, Rev, Tat, and Gag-Pol constructs into HEK293T cells with 45 $\mu$ L polyethylenimine (1  $\text{mg}/\text{mL}$ ) per  $6 \times 10^6$  cells. Transfections of HIV-1 included only viral plasmids and envelope plasmids. Supernatants of lentiviruses were collected, filtered with 0.45 $\mu\text{m}$  syringe filter (Corning), concentrated by centrifuging through a 20% sucrose gradient, and titered on CEM cells (Janas and Wu, 2009). I used a range of multiplicity of infections, but most viruses and lentiviruses within this paper were concentrated to approximately  $1 \times 10^6 \text{ IU}/\text{mL}$ .

Transfections of dCas9-KRAB in Chapter Four for the purposes of making lentiviral vectors were performed similarly. Cotransfections of pNL4-3.Luc.R-E-, dCas9-KRAB, and sgRNAs into HEK293T cells were also performed similarly but without any additional accessory or structural gene plasmids.

For transductions with CAR vectors, primary cells were stimulated for 5-6 h with 10  $\mu\text{g}/\text{mL}$  PHA, washed in PBS, and spinoculated by spinning cells with lentivirus and 5  $\mu\text{g}/\text{mL}$  polybrene (Millipore) at 1200g for 90 min. Cells were then supplemented with fresh RPMI and IL-7, cultured overnight, and washed in PBS 18 h later. Cells were rested for

one week to return to a resting state as confirmed by low CD69 expression prior to HIV-1 infection.

Transductions of Jurkat cells with CAR vectors and J-Lat cells with dCas9 vectors were performed similarly. However, no PHA stimulation or cytokine treatment was required. CAR-expressing Jurkat cells were sorted based on mCherry expression and cultured as pure populations. For sorting details, see Flow Cytometry Methods below.

### **CAR Stimulation and Infections**

Non-tissue culture treated plates were coated overnight at 37°C with 1  $\mu\text{g}/\text{mL}$  Her2 (Recombinant Human ErbB2/Her2 Fc Chimera Protein from R&D Systems, 1129-ER). Her2 solution was removed from wells, plates were washed 3 times in PBS, and wells were blocked for 1 h with a 5% FBS-PBS solution.

CAR+ Jurkat or primary CD4+ T cells were infected with HIV-1 and simultaneously plated in Her2-treated wells. For experiments in which latently infected cells were generated, cells were spinoculated in the Her2-treated wells at 1200xg for 90 min and then supplemented with fresh RPMI and IL-7. Following overnight infection, cells were washed and either lysed or maintained in fresh media in the absence of Her2.

For some experiments, CAR-expressing cells were treated with 10  $\mu\text{M}$  PP2 or PP3 (Calbiochem - Millipore Sigma), Src kinase inhibitor and pharmacologically inactive analog respectively, at the time of HIV-1 infection.

Infections of HEK293T cells with HIV-1 were performed 24 h prior to dCas9-KRAB and sgRNA transfection.

### **Electroporations**

For electroporations,  $1 \times 10^6$  J-Lat cells were centrifuged for 10 min at 90xg. Cells were then resuspended in 90  $\mu$ L 1SM buffer. 1SM buffer (5mM KCl, 15mM MgCl<sub>2</sub>, 120mM Na<sub>2</sub>HPO<sub>4</sub> pH 7.2, 25mM sodium succinate, 25mM manitol) was prepared as described in (Chicaybam *et al.*, 2013). Cells were incubated with 10  $\mu$ L sgRNA (1000 nM) in cuvettes. Electroporation was performed in Amaxa Biosystems Nucleofactor I with program setting X-005. After electroporation, cells were cultured in RPMI 1640, 20% FBS (Corning, Inc.), 100 <sup>units</sup>/<sub>mL</sub> penicillin (Invitrogen), 100 <sup>µg</sup>/<sub>mL</sub> streptomycin (Invitrogen), and 2mM L-glutamine (Invitrogen) at 37° C with 5% CO<sub>2</sub>. 24 h later, cells were washed in PBS and replated in normal culture media as described above.

### **Latency Reversal**

For reactivation of latent CAR-expressing primary cells, mCherry (CAR) positive and GFP (HIV-1) negative cells were sorted at 6 or 7 days post HIV-1 infection. Cells were cultured with the following concentrations of LRAs: 5 <sup>ng</sup>/<sub>mL</sub> PMA and either 10 or 100uM ionomycin for 2.5 h, Dynabeads human T-activator CD3/CD28 beads at a ratio to cells of 1:1 for 24 h, 50  $\mu$ M SBHA for 24 h, and 25nM Bryostatin for 24 h. Cells

reactivated with PMA were washed in PBS and re-plated in media. All reactivated cells were incubated with  $10^{\text{ng}}/\text{mL}$  IL-7. Cells were cultured overnight prior to fixation for flow analysis.

J-Lat cells were treated with  $10 \text{ ng/mL}$  TNF- $\alpha$  in order to induce latency reversal. Stimulation took place five days following electroporation. RNA was isolated for qRT-PCR 24 h post latency reversal.

### **Luciferase Analysis**

Jurkat cells were washed and lysed for luciferase analysis 24 h post infection, while primary T cells were measured at 4 days post infection. HEK293T cells were washed and lysed for luciferase analysis 48 h post sgRNA and dCas9-KRAB transfection. Luciferin (Promega) was added and luciferase activity was measured via BioTek Synergy HT Microplate Reader.

### **Flow Cytometry**

Flow data were collected on an LSRII from BD Biosciences. Zombie UV Fixable Viability Kit (BioLegend) was used as live/dead stain for reactivation experiments. All cells were washed and fixed in a final concentration of 2% paraformaldehyde prior to analysis. Cell sorting was performed on a MoFlo Astrios from Beckman Coulter. All flow experiments performed at Boston University School of Medicine Flow Cytometry Core Facility.

CAR stimulation was determined by CD69 expression (Brilliant Violet 421 anti-human CD69 antibody; Clone FN50, BioLegend).

Memory cell phenotypes were characterized based upon CCR7 and CD45RA expression (Pe/Cy7 anti-human CCR7 antibody; Clone G043H7, BioLegend and PerCP/Cy5.5 anti-human CD45RA antibody; Clone HI100, BioLegend).

### **Microarray Analysis and Heatmap Formulation**

Primary CD4<sup>+</sup> T cells were transduced with chimeric antigen receptors and allowed to return to a resting state for 1 week. Cells were then stimulated overnight with plate-bound Her2 as described above. Untransduced CD4<sup>+</sup> T cells were left unstimulated or were plated in a solution of 1  $\mu\text{g}/\text{mL}$  CD28 (Mouse Anti-Human CD28, #555725, BD Biosciences) on previously coated wells of 1  $\mu\text{g}/\text{mL}$  CD3 (Mouse Anti-Human CD3, #555329, BD Biosciences). Cells were then washed in PBS and lysed for RNA extraction using Qiagen miRNeasy Mini Kit (#217004). RNA was stored at  $-80^{\circ}\text{C}$  until delivery to the BU Microarray and Sequence Resource Core Facility. At the Microarray core, cDNA was made and samples were run on a Human Clariom S Array. The Microarray core also provide the statistical support described here.

Human Clariom S CEL files were normalized to unstimulated cells to produce gene-level expression values using the implementation of the Robust Multiarray Average (RMA) (Irizarry *et al.*, 2003) in the *affy* package (version 1.36.1) (Gautier *et al.*, 2004) including in the Bioconductor software suite (version 2.11) (Gentleman *et al.*, 2004) and

an Entrez Gene – specific probeset mapping (21.0.0) from the Molecular and Behavioral Neuroscience Institute (Brainarray) at the University of Michigan (Dai *et al.*, 2005, University of Michigan, 2019). Array quality was assessed by computing Relative Log Expression (RLE) and Normalized Unscaled Error (NUSE) using the *affyPLM* package (version 1.34.0). Analyses of variance were performed using the *f.pvalue* function in the *sva* package (version 3.4.0). Differential expression was assessed by performing Student's *t* test on the coefficients of linear models created using the *lmFit* function in the *limma* package (version 3.14.4). In this way, a one-way ANOVA *p* value was obtained using a linear mixed effects modeling approach to account for differences between donors.

Correction for multiple hypothesis testing was accomplished using the Benjamini-Hochberg false discovery rate (FDR) (Benjamini and Hochberg, 1995). All microarray analyses were performed using the R environment for statistical computing (version 2.15.1). All genes with FDR *q* values below 0.01 were plotted on a heatmap and arbitrarily separated into 5 clusters based on expression profiles.

Principal Component Analysis (PCA) was performed using the *prcomp* R function with expression values that had been normalized across all samples to a mean of zero and a standard deviation of one. The separation of samples by treatment group along the PC1 axis explains 29% of all variance in the experiment.

### Measurement of HIV-1 Provirus Using Nested *Alu*-PCR

For measuring integrated HIV-1 provirus, a nested PCR strategy was adapted from (Agosto *et al.*, 2007). Briefly, integrated HIV-1 DNA was amplified using forward primers for the luciferase sequence and reverse primers for human *Alu* (see Table 2.2). The first reaction was performed on a TProfessional Thermocycler from Biometra according to the following conditions: 4 m at 95° followed by 20 cycles of 15 s at 93°, 15 s at 50°, and 2.5 m at 70°. A second round of amplification was then performed using a forward primer, a reverse primer, and a probe for real time PCR within the HIV-1 3' R / U5 region (see Table 2.2). The amount of amplified copies of HIV-1 was determined based on an NL4-3 plasmid copy standard. The second reaction was performed on an Applied Biosystems QuantStudio 3 Real-Time PCR system with heating for 4 m at 95° and real-time PCR conditions of denaturation for 15 s at 95°, annealing for 30 s at 60°, and extension for 1 m at 72°.

<b>Oligos Used for <i>Alu</i>-PCR</b>			
Reaction	Gene / Target	Primer Direction	Primer Sequence
1 <sup>st</sup> Step	<i>Alu</i>	Forward	5'-CGTCGCCAGTCAAGTAAC-3'
	<i>luc</i>	Reverse	5'-CTGTAATCCCAGCAGTTTGGGAGGC-3'
2 <sup>nd</sup> Step	3' R/U5	Forward	5'-GCCTCAATAAAGCTTGCCTTGA-3'
		Reverse	5'-TCCACACTGACTAAAAGGGTCTGA-3'
		Probe	5'-FAM-CCAGAGTCACACAACAGACG-TAMRA-3'

**Table 2.2: Oligos used for *Alu*-PCR.** Oligos are listed for each reaction step.

### Measurement of HIV-1 mRNA by RT-PCR

#### *RT-PCR for Chapter Three*

RT-PCR for HIV-1 mRNA spliced variants was performed using forward primers and reverse primers for spliced HIV-1 *env* and *tat* sequences. RT-PCR for HIV-1 mRNA after latency reversal was performed using forward primers and reverse primers for unspliced HIV-1 *tat* sequence. All values for both assays were normalized against beta-actin as a housekeeping gene (see Table 2.3). The reaction was performed on an Applied Biosystems QuantStudio 3 Real-Time PCR system with heating for 15 m at 94° and real-time PCR conditions of denaturation for 15 s at 94°, annealing for 30 s at 60°, and

extension for 30 s at 72°. Relative levels of HIV-1 mRNA were determined by delta-delta CT.

<b>Oligos Used for RT-PCR in Chapter Three</b>		
Gene / Target	Primer Direction	Primer Sequence
<i>env</i> (spliced)	Forward	5'-TCCCTCAGACCCTTTTAGTCAG-3'
	Reverse	5'-GATTACTATGGACCACACAACACTATTG-3'
<i>tat</i> (spliced)	Forward	5'-TCCCTCAGACCCTTTTAGTCAG-3'
	Reverse	5'-CATCTGTCCTCTGTCAGTTTC-3'
<i>tat</i> (unspliced)	Forward	5'-GGAGCCAGTAGATCCTAGAC-3'
	Reverse	5'-CTTGGCAATGAAAGCAACAC-3'
<i>ACTB</i>	Forward	5'-TGGGACGACATGGAGAA-3'
	Reverse	5'-GGGTGTTGAAGGTCTCAA-3'

**Table 2.3: Oligos used for RT-PCR in Chapter Three.** Oligos are listed for each gene of interest or spliced transcript.

#### *RT-PCR for Chapter Four*

RT-PCR for HIV-1 mRNA after latency reversal was performed using forward primers and reverse primers for unspliced HIV-1 *gag* sequence, and all values were normalized against beta-globin as a housekeeping gene (see Table 2.4). The reaction was performed on an Applied Biosystems QuantStudio 3 Real-Time PCR system with heating

for 15 m at 94° and real-time PCR conditions of denaturation for 15 s at 94°, annealing for 30 s at 60°, and extension for 30 s at 72°. Primers for HIV-1 were based on Malnati *et al.*, 2008. Relative levels of HIV-1 mRNA were determined by delta-delta CT.

<b>Oligos Used for RT-PCR in Chapter Four</b>		
Gene / Target	Primer Direction	Primer Sequence
<i>gag</i>	Forward	5'-TACTGACGCTCTCGCACC-3'
	Probe	5'-FAM-CTCTCTCCTTCTAGCCTC-NFQMGB-3'
	Reverse	5'-TCTCGACGCAGGACTCG-3'
$\beta$ -globin	Forward	5'-CCCTTGGACCCAGAGGTTCT-3'
	Probe	5'-FAM-GCGAGCATCTGTCCACTCCTGATGCTGTTATGGGCGCTCGC-NFQMGB-3'
	Reverse	5'-CGAGCACTTTCTTGCCATGA-3'

**Table 2.4: Oligos used for RT-PCR in Chapter Four.** Oligos are listed for each gene of interest. HIV-1 primers span an unspliced region.

### **Chromatin Immunoprecipitation (ChIP)**

ChIP was performed according to Natarajan *et al.*, 2013 with the addition of a nuclei isolation step using Farnham Lysis Buffer prior to sonication with a BioRupter Pico. Briefly, cells were washed in PBS and fixed in a final concentration of 1% formaldehyde in methanol. Crosslinking was quenched by addition of glycine to a final

concentration of 240mM. Cells were then washed, centrifuged, and flash frozen in liquid nitrogen. Pellet was lysed in Farnham Lysis Buffer (5mM PIPES pH 8.0, 85mM KCl, 0.5% NP-40) with addition of Halt Protease and Phosphatase Inhibitor Single-Use Cocktail from ThermoFisher before centrifugation to obtain nuclei fraction. Nuclei were lysed in RIPA buffer prior to sonication in BioRupter Pico for 15 m with alternating 30 s cycles. Samples were centrifuged to remove debris and pre-cleared with addition of 50% protein A sepharose bead for 30 m at 4°C. Beads were then pelleted and supernatants were split into 100µL portions as input DNA and multiple 300µL portions for sample analysis. Samples were incubated with antibodies overnight at 4°C. Antibody-bound proteins and cross-linked DNA were isolated by addition of 50% protein A sepharose beads for 2 h at 4°C prior to centrifugation. Immunoprecipitates were washed with low salt (0.1% SDS, 1% Triton X-100, 2mM EDTA, 20mM Tris-HCl pH 8.0, 150mM NaCl), high salt (0.1% SDS, 1% Triton X-100, 2mM EDTA, 20mM Tris-HCl pH 8.0, 500mM NaCl), lithium wash (0.25M LiCl, 1% NP-40, 1% sodium deoxycholate, 1mM EDTA, 10mM Tris-HCl), and Tris-EDTA buffers (10mM Tris, 1mM EDTA) before use of elution buffer (1% SDS, 0.1M NaHCO<sub>3</sub>). Cross-linking was reversed with addition of 5M NaCl overnight at 65°C to both samples and input DNA before addition of proteinase K to isolate DNA. Sample DNA was purified using CHIP DNA Clean & Concentrator Kit (Zymo Research).

Antibodies used included anti-NELF-d (Antibody TH1L from Proteintech Group), anti-RNAPII antibody (Clone N20 from Santa Cruz Biotechnology), anti-histone

H3 antibody (Product 06-599 from Millipore Sigma), and Normal Rabbit IgG (Product 12-370 from Millipore Sigma).

Primers used for the transcriptional start site include the forward primer at +30 and the reverse primer at +239. Primers used for transcriptional elongation include the forward and reverse primers within the *tat* gene (see Table 2.5).

<b>Oligos Used for Chromatin Immunoprecipitation Assays</b>		
Gene / Target	Primer Direction	Primer Sequence
TSS* (+30)	Forward	5'-CTGGGAGCTCTCTGGCTAACTA-3'
TSS* (+239)	Reverse	5'-AGATCTCCTCTGGCTTTAC-3'
<i>tat</i> (+5379)	Forward	5'-GGAGCCAGTAGATCCTAGAC-3'
<i>tat</i> (+5482)	Reverse	5'-CTTGGCAATGAAAGCAACAC-3'

**Table 2.5: Oligos used for chromatin immunoprecipitation.** Oligos are listed for each gene region of interest. Asterisk (\*) refers to HIV-1 transcriptional start site.

### Statistical Analysis

All statistical analysis performed using unpaired student's *t* test except for Microarray Analysis as detailed above.

## **CHAPTER THREE: STRENGTH OF T CELL SIGNALING REGULATES HIV-1 REPLICATION AND ESTABLISHMENT OF LATENCY**

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<https://doi.org/10.1101/432401>.

### **INTRODUCTION**

#### *Experimental Rationale*

HIV-1 persists in a transcriptionally silent latent state in long-lived memory T cells. Although antiretroviral therapies suppress HIV-1 replication, interruption of treatment results in rapid viral rebound. Therefore, HIV-1 patients must remain on ART indefinitely, despite long term side effects, development of treatment resistance, and viral-induced inflammation (Wong *et al.*, 1997; Chun *et al.*, 1997; Harrigan, Whaley and Montaner, 1999). For this reason, one strategy currently being explored for cure efforts is “shock and kill,” in which latent HIV-1 is reactivated in conjunction with ART using latency-reversing agents. Following reactivation, infected cells are predicted to be eliminated by HIV-specific immunity or virally induced apoptosis. However, clinical trials using LRAs have only minimally perturbed the size of the viral reservoir (Sagot-Lerolle *et al.*, 2008; Archin *et al.*, 2010; Archin *et al.*, 2012).

A cure for latent HIV-1 will require a better understanding of the biochemical factors involved. Latency in chronically infected primary cells and cell lines is regulated by multiple transcriptional mechanisms including NF- $\kappa$ B activation, chromatin accessibility, provirus transcription initiation, Tat availability, P-TEFb sequestration, and transcriptional elongation (Quivy, De Walque and Van Lint, 2007; Ruelas and Greene, 2013; Agosto, Gagne and Henderson, 2015; Cary, Fujinaga and Peterlin, 2016; Agosto and Henderson, 2018). However, what is not understood is how latency is initially established within a cell and if events at the time of HIV-1 infection influence the transcriptional status of the provirus. These questions are relevant since the latent reservoir is established within the first two weeks of infection (Chun *et al.*, 1998; Whitney *et al.*, 2014). New cure strategies will need to limit the size of the reservoir at early time points.

One mechanism that could predispose HIV-1 towards active replication or transcriptional repression and latency is signaling through the T cell receptor. Engagement of the TCR and costimulatory CD28 molecule result in a multitude of cellular outcomes that influence HIV-1 replication including cytoskeleton reorganization, the activation of transcription factors, enhanced RNAPII processivity, and chromatin remodeling (Huang and Wange, 2004; Kim *et al.*, 2011; Allison *et al.*, 2016). I hypothesized that the magnitude of T cell signaling during HIV-1 infection will dictate the course of the infection. In order to manipulate signal strength received by a T cell at the time of HIV-1 infection, I utilized chimeric antigen receptors (CARs) that recapitulate T cell receptor and CD28 signaling.

### *Chimeric Antigen Receptors*

Chimeric antigen receptors or CARs are engineered ligand binding domains fused to signaling domains of interest. In this way, researchers can approximate endogenous receptor signaling but via a mechanism that they can control (Gross and Eshhar, 1992). CARs are widely used as cancer therapeutics where they can repurpose either NK cells or T cells to specifically recognize an oncogenic marker (Sommermeyer *et al.*, 2016; Romanski *et al.*, 2016). One potential target is human epidermal growth factor receptor 2. Her2 is a receptor tyrosine kinase involved in cellular activation (Lee *et al.*, 1989); its overexpression correlates with several pathologies including breast cancer (Berns *et al.*, 1992), pancreatic cancer (Yamanaka *et al.*, 1993), and glioblastomas (Ahmed *et al.*, 2010). Therefore, multiple labs have attempted to use chimeric antigen receptors specific for Her2 in order to drive CD8<sup>+</sup> T cells towards elimination of Her2<sup>+</sup> cells. For instance, in a Phase I clinical trial for patients with Her2-specific pancreatic cancer, at least one patient achieved a 50% reduction in the number of his lesions (Feng *et al.*, 2018).

The recognition component of the Her2 chimeric antigen receptor used in my system consists of a single-chain variable fragment (scFv). Single-chain variable fragments engineered to bind Her2 were originally developed in the 1990's. Schier *et al.* screened a scFv library and discovered the C6.5 fragment, which was later mutated to produce a number of other scFvs with differing affinities for the Her2 ligand (Schier *et al.*, 1996). This panel of Her2 receptors span 3 logs of affinity for their cognate antigen. The Wong laboratory at Boston University cloned these ligand-binding domains onto a

receptor with the intracellular signaling domains of CD3 $\zeta$  and CD28, the two main components of the T cell receptor signaling complex. CD3 $\zeta$  contains the six critical ITAMs (immunoreceptor tyrosine-based activation motifs) that are responsible for signal transduction due to their capacity to become phosphorylated (Bettini *et al.*, 2017). CD28 also contains multiple tyrosine residues that become phosphorylated, although they do not form a classic ITAM motif (Natarajan, August and Henderson, 2010; Ogawa *et al.*, 2013). By providing Her2 to this system, I aimed to induce similar signaling cascades to those activated by T cell receptor recognition of a MHC-peptide complex. Through these chimeric antigen receptors, which are identical apart from their Her2-binding domain, I was able to modulate the strength of signal that a cell receives. Differences in Her2 binding correlated with differential induction of T cell responses, providing our lab with a tool to manipulate cellular stimulation at the time of viral infection. A similar approach, in which various CD3 $\zeta$  ITAMs were mutated to prevent phosphorylation, resulted in phenotypic and functional differences in CAR-expressing CD8<sup>+</sup> T cells (Feucht *et al.*, 2018). This study provided supporting evidence for my hypothesis that signaling differences downstream from a TCR-based CAR could be used to interrogate the role of the TCR on HIV-1 expression.

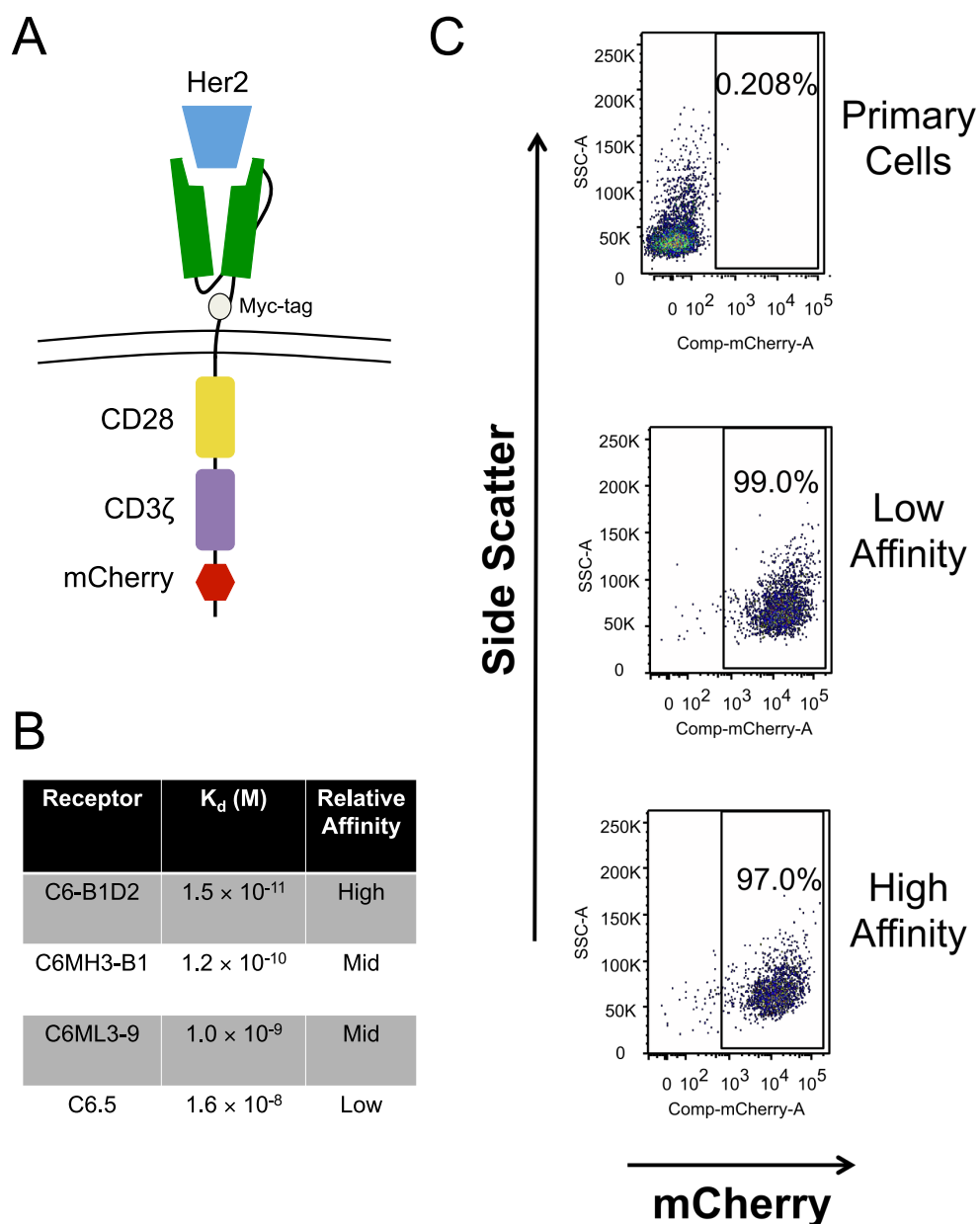
Using these CARs, I demonstrate that induction of stronger T cell receptor signaling at the time of HIV-1 infection increases subsequent HIV-1 transcription and replication. Robust signals also facilitated the formation of latently infected cells that were readily inducible upon secondary stimulation with phorbol esters, as well as PKC agonists. Minimal signaling through CARs, although sufficient for HIV-1 integration,

failed to support robust viral expression and interestingly, generated a deep-seated latent infection. Transcriptional elongation of HIV-1 provirus was limited by RNAPII pausing in the absence of CAR signaling; however, strong CAR signaling correlated with decreased Negative Elongation Factor binding and enhanced RNAPII processivity. My results suggest a model in which signaling strength influences HIV-1 transcription and establishment of latency at the time of initial infection of CD4<sup>+</sup> T cells.

## RESULTS

### *CARs Induce T Cell Signaling*

To examine how signaling cascades downstream from the T cell receptor regulate HIV-1 transcription, I utilized CARs as can be seen in Figure 3.1A. Intracellular signaling domains for the CARs include CD3 $\zeta$  with its ITAMs and the CD28 costimulatory domain with its four critical tyrosine residues (Chmielewski, Hombach and Abken, 2014). Furthermore, a mCherry tag provides a marker for positive selection of CAR<sup>+</sup> cells. The extracellular ligand-binding domains of the CARs consist of a single chain variable fragment that recognizes receptor tyrosine-protein kinase erbB-2 (Her2) (Schier *et al.*, 1996; Chmielewski, *et al.*, 2004). By using different scFvs, a library of CARs with variable binding affinities for Her2 ligand spanning three logs was generated (Figure 3.1B). CARs were transduced into Jurkat T cells and primary CD4<sup>+</sup> T cells. By enriching for mCherry, I obtained CAR<sup>+</sup> populations that were >90% pure (Figure 3.1C).



**Figure 3.1: Chimeric antigen receptors used for tunable T cell signaling.** (A) The design of CARs including CD3 $\zeta$  and CD28 signaling domains. (B) CAR single chain variable fragments with their corresponding dissociation constants for the Her2 ligand. I refer to these CARs by their relative ligand affinity. (C) Enrichment of primary CD4<sup>+</sup> T cells based on mCherry expression following CAR transduction. See also Figures 3.2 and 3.3.

I examined whether stimulation through the CARs lead to global transcriptional changes consistent with T cell receptor engagement. These changes would include both upregulation of activation markers and key cytokines as well as corresponding downregulation of other gene networks in order to dampen the level of immune activation. To analyze the effect of Her2 stimulation on CAR-expressing cells, I cultured low affinity and high affinity CAR-expressing primary CD4<sup>+</sup> T cells with plate-bound Her2 ligand for 24 h as well as untransduced CD4<sup>+</sup> T cells with or without CD3 and CD28 antibodies. I then extracted the RNA and performed microarray analysis using a Human Clariom S array. All gene expression levels were compared to the baseline of unstimulated cells, and those genes whose one-way Anova FDR-corrected  $q$  values were less than 0.01 were selected. This allowed for the creation of a heatmap of 4,966 significantly modified genes clustered based on their expression profiles. Clusters 4 and 5 represent genes that are downregulated upon cell activation, while Clusters 1 and 3 represent genes that are clearly upregulated upon cellular stimulation. As can be seen in Figure 3.2, stimulation through the low or high affinity CARs represents intermediate phenotypes between that of the unstimulated or TCR-engaged populations. The log<sub>2</sub> expression of a selection of well-known genes from Clusters 1 and 3 are listed in Table 3.1. Our lab is interested in further exploring how suboptimal cellular activation leads to unique phenotypes. However, for the purposes of this paper, the pathways and genes expected to be activated downstream from the T cell receptor pathway are indeed being engaged, confirming that binding of the receptors provide me with a way to activate a range of signaling inputs at the time of infection.

	Untransduced CD4 <sup>+</sup>			Low Affinity + Her2			High Affinity + Her2			Anti – CD3/CD28		
	Donor 1	Donor 2	Donor 3	Donor 1	Donor 2	Donor 3	Donor 1	Donor 2	Donor 3	Donor 1	Donor 2	Donor 3
CD69	6.6	6.7	7.2	7.9	7.9	8.0	8.3	8.3	8.2	8.3	8.2	7.8
PDCD1	5.6	5.9	5.6	6.0	6.2	6.5	6.7	6.4	6.9	6.6	7.0	7.3
CTLA4	4.5	4.6	5.4	5.8	6.1	6.0	6.3	6.5	6.4	6.9	6.9	6.8
IL2	1.7	1.5	1.3	3.5	4.3	3.7	4.8	4.9	4.9	6.9	7.8	7.3
IL21R	3.4	3.3	3.6	4.5	4.5	4.1	4.7	4.6	4.3	5.1	4.7	4.7
IRF4	7.8	7.7	7.3	8.7	9.5	9.3	9.0	9.3	9.3	9.1	9.1	9.3
IFNG	2.3	4.7	6.4	3.4	5.2	6.7	4.3	6.7	7.5	8.3	9.2	10.8
TNF	6.5	6.5	7.2	6.7	6.5	7.1	7.1	7.3	7.6	8.3	8.5	8.8
TRAF1	7.5	7.6	7.8	8.3	8.0	8.1	8.5	8.0	8.3	8.2	8.1	8.4
KLF10	6.0	7.0	6.4	7.8	7.9	7.9	8.1	8.1	8.3	8.1	8.4	8.6
JUN	4.2	4.8	5.2	5.5	5.3	6.0	5.7	5.9	6.1	5.5	6.0	6.2
FOXP3	6.9	6.4	6.9	6.6	6.6	6.7	6.6	6.5	6.4	7.7	7.0	7.3
CDK2	7.0	7.8	7.7	7.7	8.4	7.5	8.0	8.6	7.6	9.2	9.1	8.8

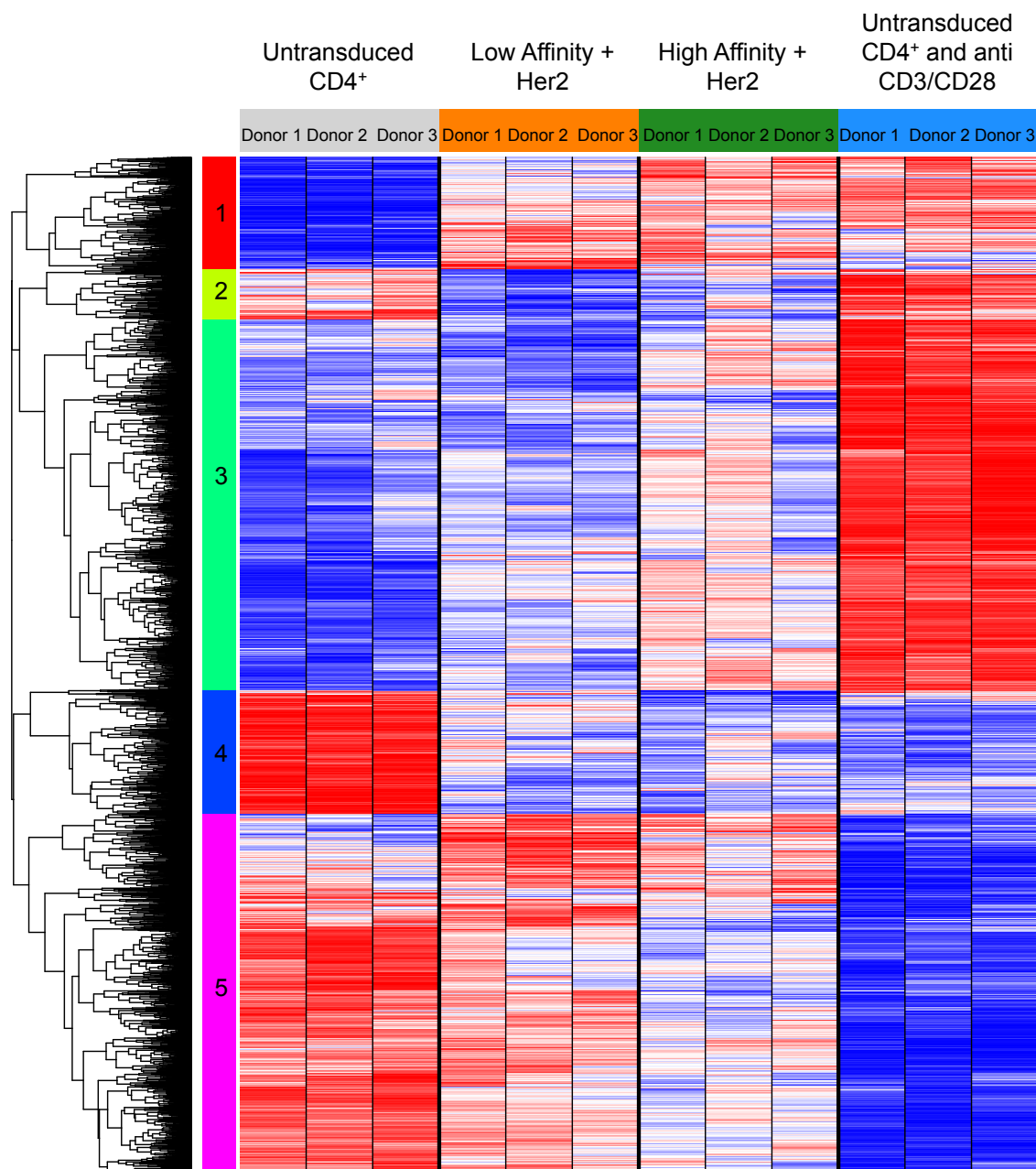
**Table 3.1: Log<sub>2</sub> expression of differentially regulated genes upon cell activation.** A selection of commonly described genes located in Clusters 1 and 3 from the heatmap shown in Figure 3.2 are presented along with their log<sub>2</sub> expression values. This list is in no way comprehensive and is shown as an example of the types of genes upregulated upon CAR stimulation.

Principal component analysis was also performed on the genes identified as significantly different from the unstimulated CD4<sup>+</sup> T cell condition. This analysis, along with the full list of genes used for the creation of the heatmap in Figure 3.2 is provided in the Appendix.

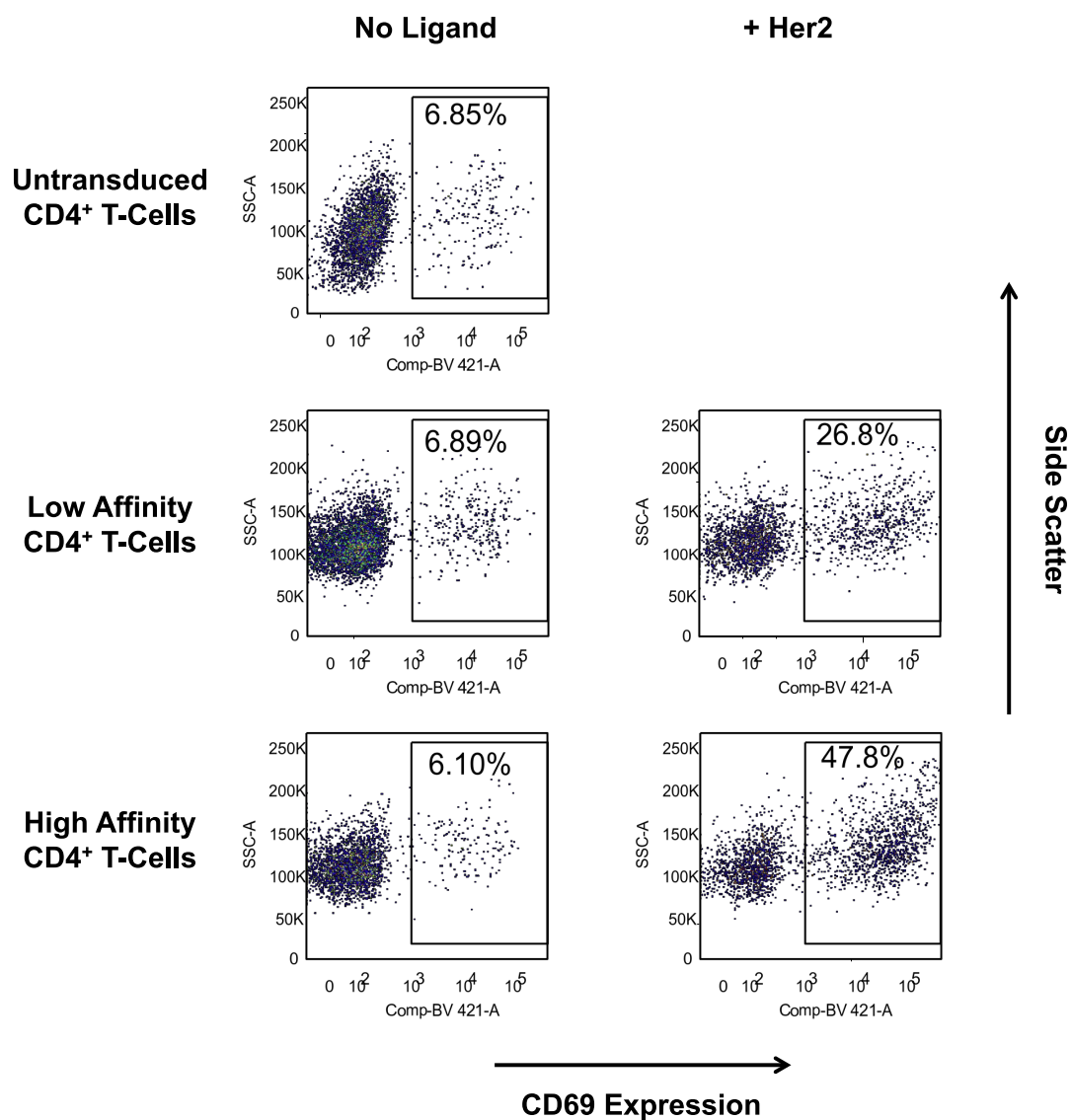
Cells were also examined for the expression of phenotypic markers following stimulation. I monitored CD69, a transmembrane lectin and a marker for CD4<sup>+</sup> T cell activation, by flow cytometry before and after receptor activation with Her 2 (Figure 3.3). Primary CD4<sup>+</sup> T cells transduced with either the low affinity or the high affinity receptors were stimulated with plate-bound Her2 ligand for 24 h. In the absence of ligand, less than 7% of the cells were positive for CD69, verifying that there is no ectopic

CAR signaling. Activating cells with Her2 induced CD69 expression in the low affinity and high affinity receptors relative to their affinity for ligand.

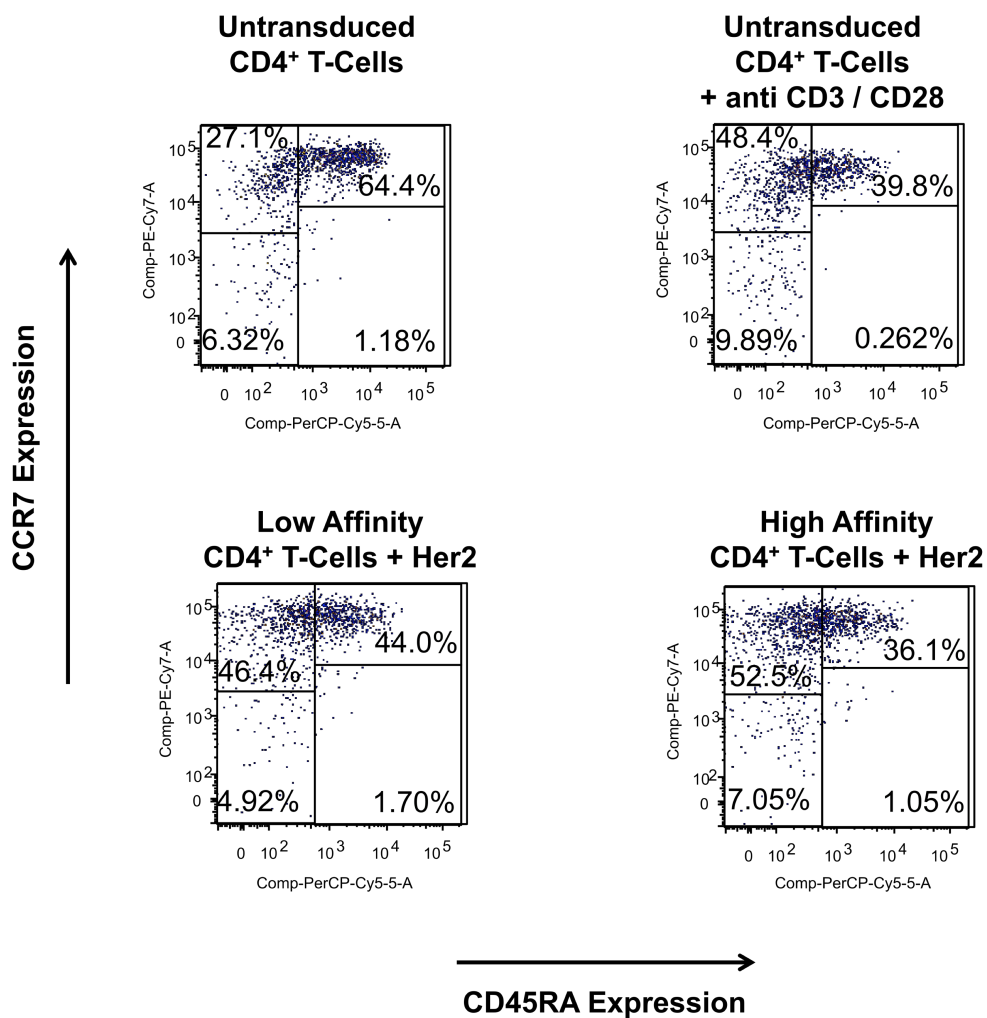
I also looked at markers associated with T cell maturation. One week post stimulation, primary cells stimulated through either the low or high affinity receptor were analyzed for expression of memory markers CCR7 and CD45RA. CCR7 is a lymph node homing receptor, and CD45RA is downregulated upon memory cell differentiation. Activation through the endogenous T cell receptor using antibodies to CD3 and CD28 resulted in the expansion of the CCR7<sup>+</sup> CD45RA<sup>-</sup> central memory population and to a lesser extent a CCR7<sup>-</sup> CD45RA<sup>-</sup> pool of effector memory cells (Figure 3.4). CAR engagement regardless of receptor affinity polarized cells towards similar memory cell phenotypes. Taken together, these data demonstrate that CARs can be used to activate a spectrum of T cell responses and provide a tool to modulate T cell signaling. Importantly, the CARs do not drive cells towards an aberrant phenotype.



**Figure 3.2: Signaling through chimeric antigen receptors alters the expression of genes downstream from the T cell receptor.** CD4<sup>+</sup> T cells isolated from healthy human donors were transduced with low affinity or high affinity CARs and then allowed to return to a resting state. Cells were either then stimulated through the receptor or left unstimulated. RNA was isolated 24 h later and converted to cDNA before being run on a Human Clariom S array. Gene expression levels for both cell types and TCR-stimulated CD4<sup>+</sup> T cells were compared to unstimulated cells. All genes with a one-way Anova FDR-corrected  $q$  value of  $< 0.01$  were plotted in a heatmap and clustered according to expression profiles. Data is presented as a heatmap based on RNA expression and represents three independent donors.



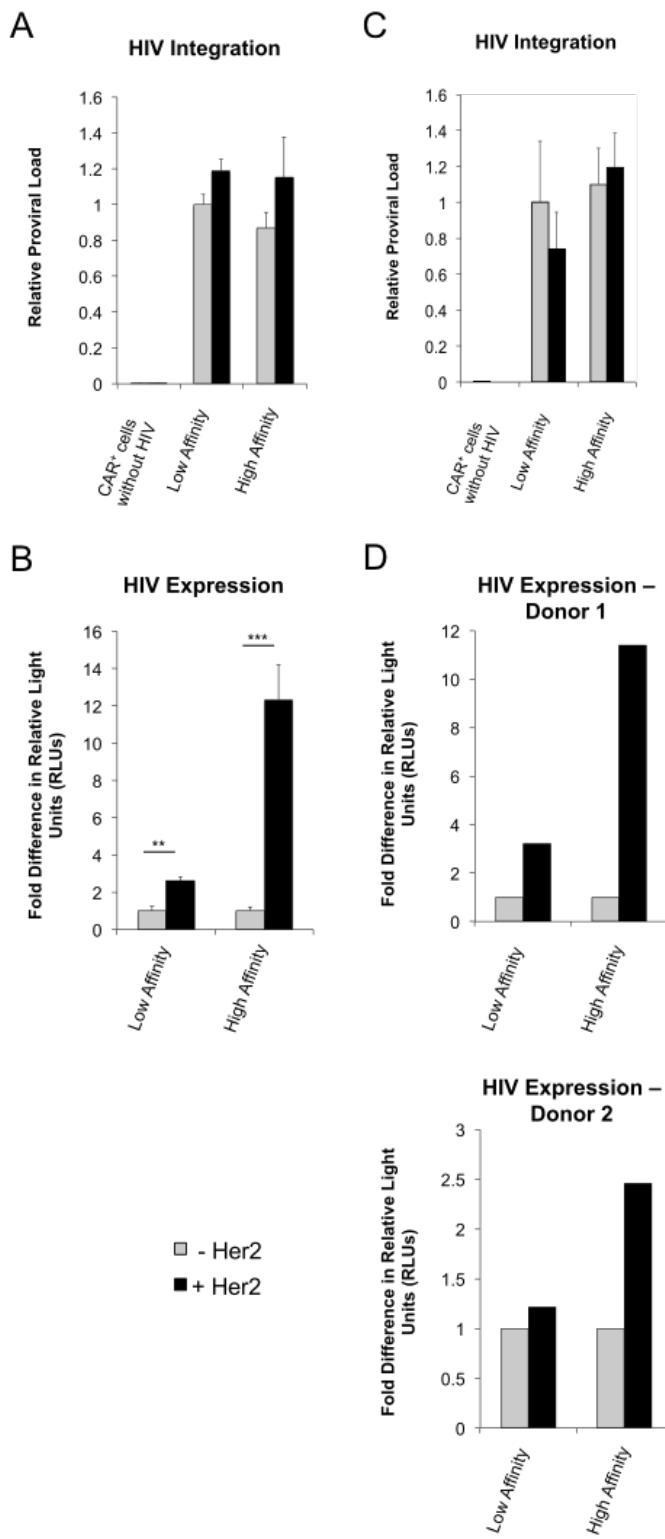
**Figure 3.3: Differential signaling through chimeric antigen receptors.** CD4<sup>+</sup> T cells isolated from healthy human donors were transduced with low affinity or high affinity CARs and then allowed to return to a resting state. Cells were either then stimulated through the receptor or left unstimulated. CD69 expression was compared to a negative control of untransduced cells one day after Her2 stimulation. Data is presented as dot plots based on flow cytometry analysis and is from a representative experiment that has been performed four times with different donors.



**Figure 3.4: Signaling through chimeric antigen receptors polarizes cells towards a central memory phenotype.** CD4<sup>+</sup> T cells isolated from healthy human donors were transduced with low affinity or high affinity CARs and then allowed to return to a resting state. Cells were then stimulated through the receptor for two days and compared to untransduced cells treated with or without antibodies to CD3 and CD28 at a ratio of 1:1. Analysis was performed 7 days post stimulation, and cells were cultured in IL-7 and IL-2 during the intervening period. The use of CCR7 and CD45RA can be used to classify cells into three distinct populations: CCR7<sup>+</sup> CD45RA<sup>+</sup> naïve-like cells, CCR7<sup>+</sup> CD45RA<sup>-</sup> central memory cells, and CCR7<sup>-</sup> CD45RA<sup>-</sup> effector memory cells. Data is presented as dot plots based on flow cytometry analysis and is from a representative experiment that has been performed three times with different donors.

*T Cell Signaling at the Time of HIV-1 Infection Regulates Provirus Expression*

To determine whether T cell signaling influences viral infection, Jurkat T cells expressing low affinity or high affinity CARs were plated on Her2-coated wells and simultaneously infected with VSV-G pseudotyped NL4-3.Luc, a single-cycle HIV-1 clone which contains a luciferase reporter gene in place of *nef*. VSV-G or Vesicular Stomatitis Virus Envelope Glycoprotein G allowed me to bypass potentially confounding effects from receptor/chemokine receptor signaling due to gp120 binding (Davis *et al.*, 1997) and focus specifically on CAR-associated signaling cascades. To assess whether signaling influenced the establishment of infection, I measured levels of HIV-1 proviral DNA using a previously described nested *Alu*-PCR approach (Agosto *et al.*, 2007). I modified the assay by designing primers to the luciferase open reading frame to estimate the relative frequency of HIV-1 integration without confounding signals from the lentiviral vectors used to express the CARs (see Chapter 2). CAR-associated signaling did not affect the infection of Jurkat cells since I detected comparable numbers of proviruses regardless of the presence or absence of CAR ligand (Figure 3.5A). When HIV-1 expression was measured by luciferase activity, Jurkat cells infected in the context of strong CAR signaling expressed greater than 10-fold more HIV-1 compared to untreated controls (Figure 3.5B). In contrast, engagement of the low affinity CAR led to a modest 3-fold expression compared to unstimulated cells despite a similar proviral load as the high affinity CAR-expressing cells. These data indicate that strong T cell signaling at the time of infection facilitates HIV-1 expression without enhancing provirus integration.



**Figure 3.5: T cell signaling at the time of HIV-1 infection regulates provirus expression.**

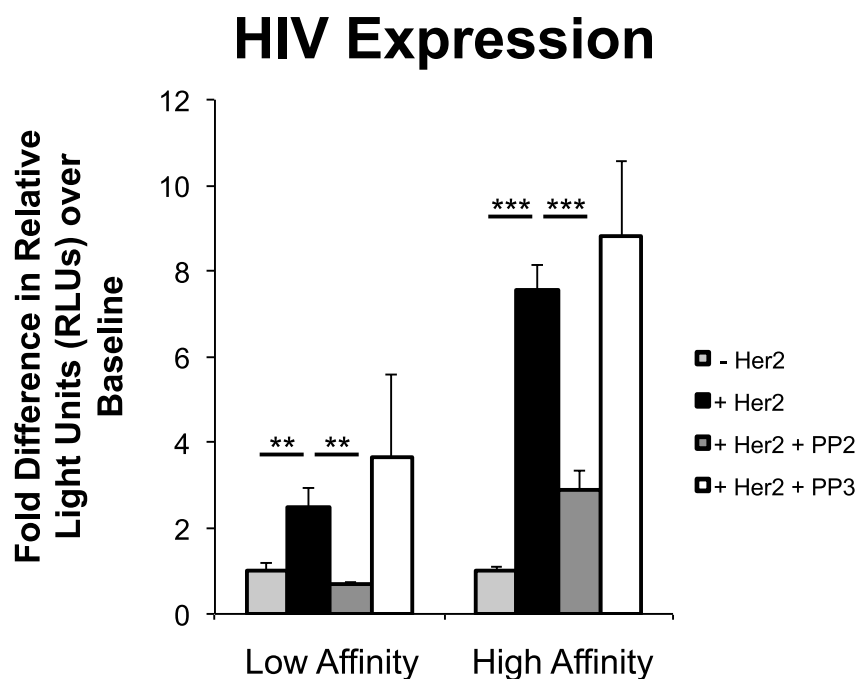
(A and B) Jurkat T cells were transduced with the high or low affinity CAR. Cells were stimulated through the CAR at the time of HIV-1 infection with VSV-G pseudotyped NL4-3.Luc. (A) Relative levels of integrated provirus 24 h post infection of high or low affinity Jurkat T cells using nested *Alu*-PCR. Uninfected CAR-expressing Jurkat T cells were a negative control. (B) Luciferase activity measured 24 h post-infection presented as fold difference in relative light units (RLUs) over unstimulated cells for each CAR+ cell line. \*\* $p < 0.005$ , \*\*\* $p \leq 0.0005$ . A and B were performed in triplicate and are representative of four independent experiments. Data are presented as mean  $\pm$  standard deviation. (C and D) Primary CD4<sup>+</sup> T cells isolated from healthy human donors were transduced with CARs and given one week to return to a resting state. Cells were stimulated through the CAR at the time of HIV-1 infection with single-round VSV-G pseudotyped NL4-3.Luc. (C) Relative levels of integrated provirus 24 h after infection of high or low affinity CAR-expressing primary T cells (from the same donor) using nested *Alu*-PCR. Uninfected CAR-expressing primary T cells were a negative control. Results are from a single experiment performed in triplicate and are representative of two independent experiments. Data are presented as mean  $\pm$  standard deviation. (D) Luciferase activity measured 4 days post infection presented as fold difference in RLUs over unstimulated cells for each CAR+ cell line. Experiments from two separate donors are shown and are representative of three independent experiments. See also Figure 3.6 and 3.7.

I confirmed that these differences were due to downstream signaling cascades emanating from the CARs by using the Src kinase inhibitor, PP2. Src kinases are the first downstream targets of T cell receptor activation and are recruited to the phosphorylated ITAMs (Gibson *et al.*, 1996; Rossy *et al.*, 2013). In the presence of PP2, the increase in HIV-1 expression upon CAR stimulation was attenuated, consistent with T cell signaling as a regulator of HIV-1 expression (Figure 3.6). The pharmacologically inactive version of this inhibitor, PP3, had no effect on the ability of CARs to influence HIV-1 expression.

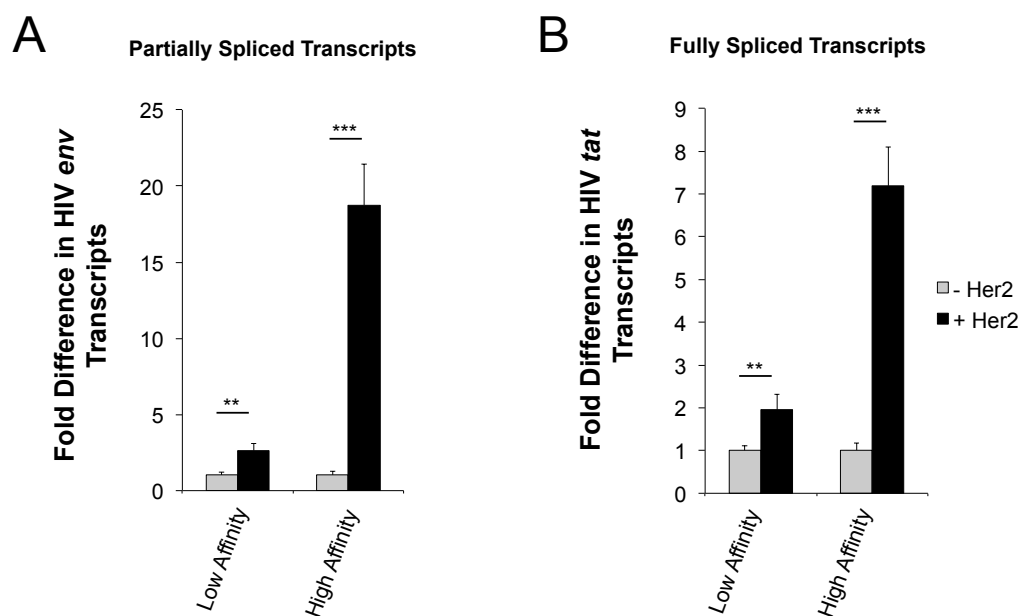
To confirm that differences in luciferase activity were a result of transcriptional upregulation and not post-transcriptional events, I examined production of spliced viral mRNAs in HIV-1 infected CAR-expressing Jurkat T cells. A major impediment to successful HIV-1 replication occurs at the level of splicing (Yukl *et al.*, 2018). I analyzed infected Jurkat cells to measure whether increased cellular activation resulted in increased expression of fully-spliced and partially-spliced viral transcripts. RT-PCR confirmed that increased cellular activation resulted in not only greater levels of fully-

spliced RNA transcripts but also partially-spliced transcripts (Figure 3.7). Although differences were detected between the amount of partially-spliced and fully-spliced mRNAs, this effect was most likely due to primer binding efficiencies or splicing kinetics (Klotman *et al.*, 1991; Puray-Chavez *et al.*, 2017). In addition, not all products are spliced in equal ratios, with *env* transcripts being relatively highly expressed (Ocwieja *et al.*, 2012). Regardless, the fact that all measured spliced products increased upon greater T cell stimulation indicated that transcription was the limiting step of HIV-1 expression in response to TCR signaling.

I validated the observation that signal strength influenced HIV-1 replication and transcription using primary CD4<sup>+</sup> T cells that were transduced with either the low affinity or high affinity CAR. Following transduction, cells were allowed to return to a resting state as monitored by low CD69 expression before infection with HIV-1 in the absence or presence of the ligand Her2. Consistent with the data from Jurkat cells, similar levels of proviral DNA were detected in primary CD4<sup>+</sup> T cells regardless of the strength of CAR signaling (Figure 3.5C). Cells that received robust stimulation at the time of infection expressed 1.5- to 4-fold more HIV-1 than cells stimulated through the low affinity receptor (Figure 3.5D).



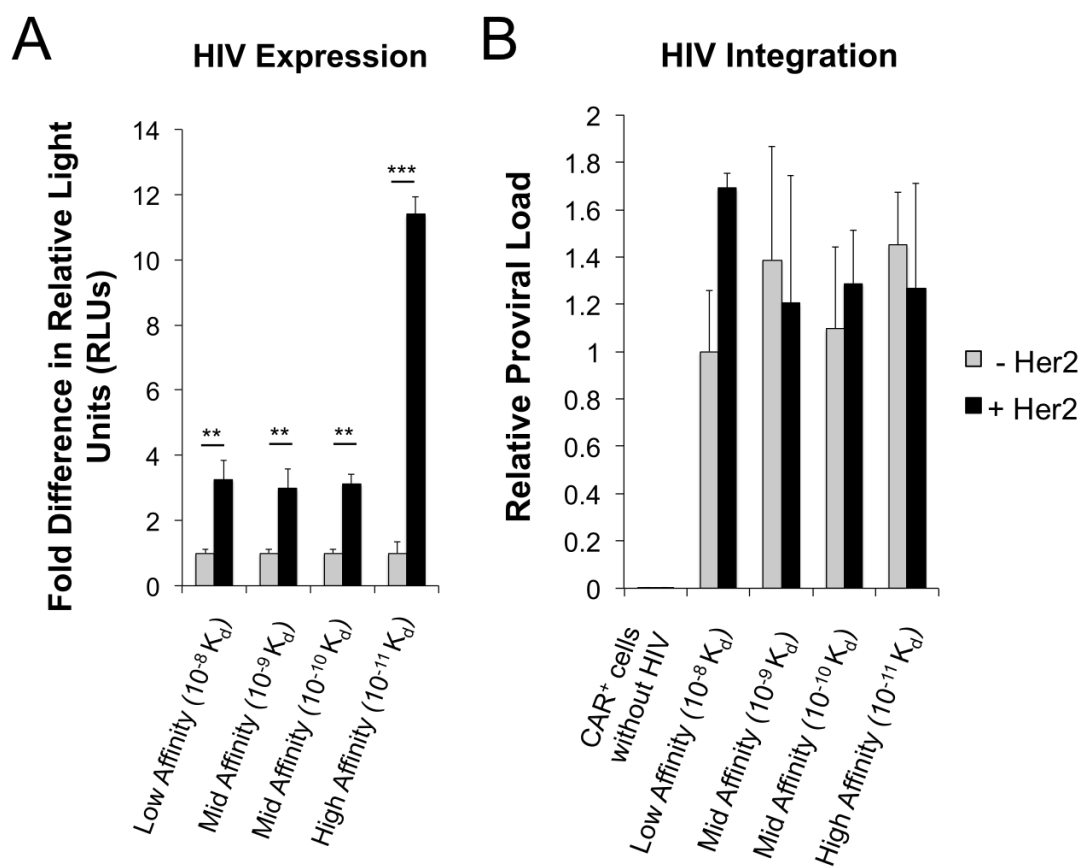
**Figure 3.6: Src kinase inhibitor PP2 inhibits CAR-mediated HIV-1 transcription.** CAR+ Jurkat T cells were stimulated with or without Her2 in the absence or presence of 10 $\mu$ M PP2 or PP3 at the time of HIV-1 infection with single-round VSV-G pseudotyped NL4-3.Luc. 24 h post infection, cells were lysed to measure luciferase. Data are presented as fold difference in RLU over unstimulated cells for each CAR+ population. \*\* $p < 0.005$ , \*\*\* $p \leq 0.0005$ . Figure 3.6 was performed in triplicate and is representative of five independent experiments. Data are presented as mean  $\pm$  standard deviation.



**Figure 3.7: T cell signaling at the time of HIV-1 infection regulates provirus expression by inducing transcription.** (A and B) CAR+ Jurkat T cells were stimulated with or without Her2 at the time of HIV-1 infection with VSV-G pseudotyped NL4-3.Luc. 24 h post infection, cells were lysed in order to measure HIV-1 transcripts by qRT-PCR. (A) Fold difference in HIV-1 *env* transcripts over corresponding unstimulated conditions as an indication of production of partially spliced RNAs. Although *env* gene is heavily deleted in provirus, the 5' end of the gene remains intact. (B) Fold difference in HIV-1 *tat* transcripts over corresponding unstimulated conditions as an indication of production of fully spliced RNAs. \*\* $p < 0.005$ , \*\*\* $p < 0.0005$ . A and B were performed in quadruplicate. Data are presented as mean  $\pm$  standard deviation.

To gain insight into whether there is a threshold or minimal T cell signal required for HIV-1 infection and replication, I transduced Jurkat T cells with CAR receptors that spanned a range of binding affinities (Figure 3.1B). These cells were infected with NL4-3.Luc as described above in the absence or presence of Her2. Although the high affinity condition supported HIV-1 infection and transcription, the intermediate and low affinity receptors did not support HIV-1 expression (Figure 3.8A). This was despite similar levels of infection as determined by measuring proviral DNA (Figure 3.8B). These data suggest

that T cell signaling controls HIV-1 expression by a digital on/off mechanism since viral expression does not linearly correlate with signal strength.

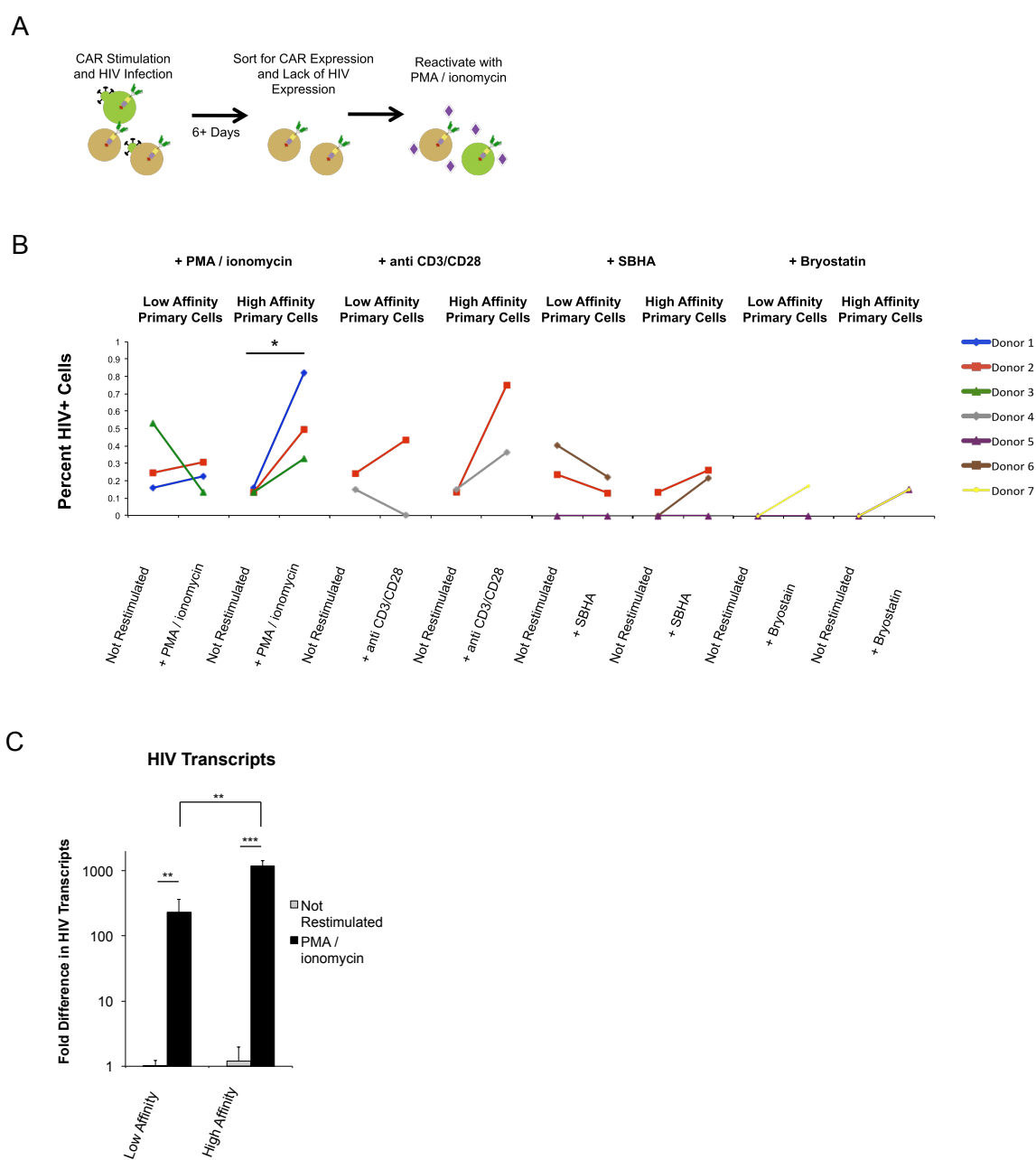


**Figure 3.8: Robust T cell signaling is required for HIV-1 transcription.** (A) Jurkat T cells were transduced and positively selected for indicated CARs and then infected with NL4-3.Luc. 24 h post infection, cells were lysed for luciferase analysis. Data are presented as fold difference in RLUs over unstimulated cells for each CAR<sup>+</sup> population. \*\* $p < 0.005$ , \*\*\* $p < 0.0001$ . (B) Relative levels of integrated provirus after infection of CAR-expressing Jurkats using nested *Alu*-PCR. A and B were performed in triplicate and are representative of four independent experiments. Data are presented as mean  $\pm$  standard deviation.

*Robust Signals During HIV-1 Infection Establishes an Inducible Latent Reservoir*

I hypothesized that differential T cell signaling during infection alters the size of the inducible latent reservoir. To examine this, I infected CAR-expressing primary CD4<sup>+</sup> T cells with VSV-G pseudotyped Bru-dENV-GFP (GFP-expressing single cycle HIV-1) in the presence of Her2 ligand. One week post infection, cells were sorted for both mCherry expression as a marker for CAR transduction and lack of GFP expression in order to enrich for latently infected cells. CAR<sup>+</sup>/GFP<sup>neg</sup> cells were reactivated with PMA plus ionomycin or left unstimulated to control for spontaneous HIV-1 reactivation (Figure 3.9A). PMA, a phorbol ester, and ionomycin, a calcium ionophore, engage two separate arms of the T cell activation pathway. PMA and ionomycin significantly reactivated HIV-1 expression within cells that had been initially infected in the context of strong signaling, resulting in a 3- to 9-fold increase in the percentage of GFP positive cells and a 1000-fold induction of HIV-1 mRNA measured by qRT-PCR (Figure 3.9B and 3.9C). However, the observed reactivation of HIV-1 was modest in cells infected at the time of stimulation through the low affinity CAR. A 200-fold induction of HIV-1 RNA was detected in reactivated latently infected cells expressing low affinity CARs, and less than a 2-fold change was observed in the percentage of GFP<sup>+</sup> cells. Therefore, despite both minimal and robust signaling resulting in comparable amounts of integrated HIV-1 provirus, robust signaling was not only necessary for active transcription but also supported the generation of a population of latently infected cells that could be readily induced to express HIV-1. The population of latent cells generated in response to weaker

CAR signaling was more resistant to reversal suggesting that HIV-1 in these cells was strongly repressed.



**Figure 3.9: Robust signals during HIV-1 infection establish an inducible latent reservoir.** (A) Outline of experimental plan to enrich for latently infected cells following infection. Primary CD4<sup>+</sup> T cells are infected with BRU-dEnv-GFP and GFP-negative cells are sorted to enrich for latently infected cells. (B) Percent GFP<sup>+</sup> HIV-expressing cells after stimulation of latent cells with various latency-reversing agents: PMA plus ionomycin, antibodies to endogenous CD3 and CD28, SBHA, and Bryostatin. Data are from seven separate donors, and each form of LRA stimulation was performed on cells from 2-3 donors. (C) Latently-infected cells were restimulated with PMA and ionomycin. HIV-1 expression was monitored by measuring Tat RNA by qRT-PCR. Values are shown as fold difference in HIV-1 transcripts over corresponding non-reactivated controls. All data in C are derived from 4-6 replicates and are representative of three independent experiments with different donors. Data are presented as mean  $\pm$  standard deviation. \*p<0.05, \*\*p<0.005, \*\*\*p<0.0001.

I also used other common latency-reversing agents in order to determine if targeting alternative activation pathways could reverse the refractory nature of the low stimulation cells. Antibodies to CD3 and CD28, which would engage the endogenous T cell receptors and fully re-activate these cells, failed to reverse the repressed virus in cells that expressed the low affinity CAR. SBHA (an HDACi) and bryostatin (a PKC agonist) failed to significantly reactivate cells that had received either high or low levels of stimulation at the initial time of infection. (Figure 3.9B).

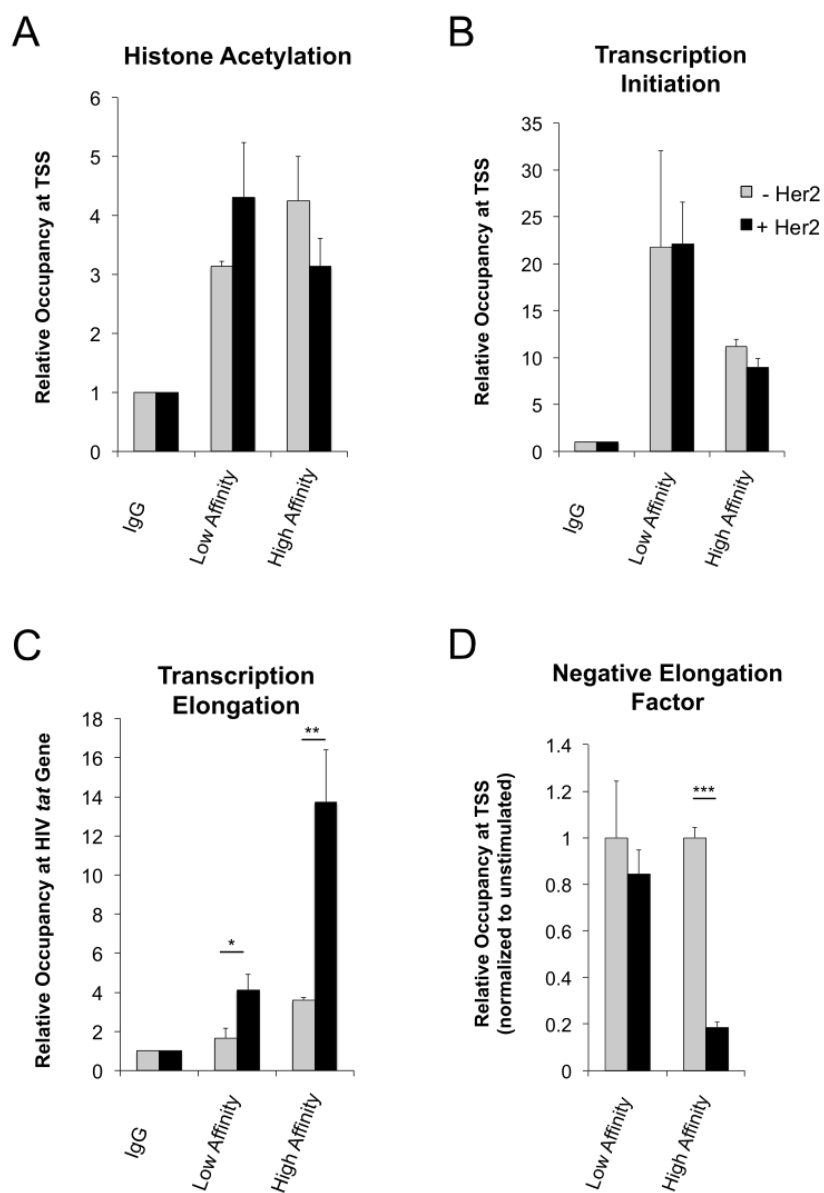
*RNAPII Processivity Limits HIV-1 Transcription in the Absence of Robust Signaling*

I was interested in mechanisms that governed HIV-1 repression following integration in the absence of sufficient T cell signaling; therefore, I examined the binding of transcriptional regulators on the HIV-1 LTR by chromatin immunoprecipitation (ChIP). Jurkat T cells expressing low or high affinity CARs were infected with NL4-3.Luc in the absence or presence of Her2 ligand. One day post-infection, cells were fixed and chromatin was prepared for ChIP.

Since HIV-1 proviral latency correlates with a positioned nucleosome that is downstream of the transcriptional start site, I explored whether the LTR was associated with post-translationally modified histones as an indicator of chromatin organization. ChIPs for acetylated histone H3 showed no significant difference in binding of the HIV-1 LTR between cells infected in the absence or presence of T cell signaling (Figure 3.10A). Taken together with the lack of effect of histone deacetylase inhibitors on latency reversal (Figure 3.9B), it would seem that chromatin accessibility does not appear to be limiting HIV-1 proviral transcription during the early stages of infection.

I then examined RNAPII processivity by measuring RNAPII occupancy at multiple points in the HIV-1 proviral genome, including the transcriptional start site and downstream in the HIV-1 *tat* gene. RNAPII was detected at the HIV-1 transcriptional start site whether cells were activated through a CAR or were unstimulated (Figure 3.10B). However, signaling through the high affinity receptor resulted in an increase in downstream RNAPII by greater than 4-fold, whereas only modest levels of RNAPII were found downstream in the absence of signals or following weak signaling (Figure 3.10C).

Since these data indicated a role for transcriptional pausing, I examined if CAR signaling altered the presence of the pausing factor NELF at the HIV-1 transcriptional start site. Using ChIPs, I determined that signaling through the high affinity receptor diminished binding of NELF at the HIV-1 LTR by greater than 85% (Figure 3.10D). These data support a model in which a lack of robust T cell signaling limits HIV-1 transcription by establishing a paused polymerase complex.



**Figure 3.10: RNAPII processivity limits HIV-1 transcription in the absence of robust signaling.**

CAR-expressing Jurkat T cells were infected with single-round VSV-G NL4-3.Luc and simultaneously plated with or without Her2 ligand. 24 h later, cells were fixed for chromatin immunoprecipitation. (A) ChIP for presence of acetylated H3 near the transcriptional start site (nuc-1). (B) ChIP for RNAPII at the HIV-1 transcriptional start site. (C) ChIP for RNAPII associated with the HIV-1 *tat* gene to measure polymerase processivity. Data from A-C are normalized to corresponding IgG controls for each stimulation condition. (D) ChIP for NELF-d at the HIV-1 transcriptional start site. Data is normalized to corresponding unstimulated condition for each CAR+ cell line. A-D were performed in triplicate and are representative of at least three independent experiments in Jurkat T cells. Data are presented as mean  $\pm$  standard deviation. Primers used for HIV-1 transcriptional start site are +30 and +239. Primers used for *tat* gene are +5379 and +5482. \* $p < 0.05$ , \*\* $p < 0.005$ , \*\*\* $p \leq 0.0005$

## DISCUSSION

Previous studies suggest that cell signaling may be a key regulator of HIV-1 expression and latency. The latent reservoir is enriched for antigen specific T cells, including those that respond to CMV, HSV, tuberculosis, and HIV (Douek *et al.*, 2002; Demoustier *et al.*, 2002; Casazza *et al.*, 2009; Geldmacher *et al.*, 2010; Hu *et al.*, 2016). Furthermore, the use of superantigens during viral entry increases HIV-1 replication (Laurence, Hodtsev and Posnett, 1992). Partial activation, cellular polarization, cell-to-cell contact, and/or infection of resting quiescent cells through perturbation have also been suggested to bias infections towards latency (Agosto and Henderson, 2018; Saleh *et al.*, 2007; Bosque and Planelles, 2009; Pace *et al.*, 2011; Agosto *et al.*, 2018; Kumar *et al.*, 2018). Therefore, the extent of cell activation is a key determinant in regulating the course of HIV-1 infection including the formation of the reservoir.

I have shown that differential signaling through CARs, which mimic TCR signaling, influences HIV-1 transcription and latency. In the lymph node, the primary site for both HIV-1 replication and the persistent latent reservoir (Biberfeld *et al.*, 1986; Shen *et al.*, 2003; Aid *et al.*, 2018), T cells sample lymph node resident antigen presenting cells in search for antigen. Some of these interactions, facilitated by the presentation of the T cell cognate antigen, will result in robust T cell activation, clonal expansion, and changes in gene expression. However, most MHC complexes will lack cognate antigen and initiate weak signaling (Zehn, Lee and Bevan, 2009; Martinez *et al.*, 2016). Using multiple CARs whose affinities for the Her2 ligand span several logs, I delivered a range of signaling inputs to model the spectrum of T cell receptor signaling events. My data

indicates that stronger T cell activation at the time of infection, which would be akin to antigen-specific responses, correlates with robust HIV-1 expression as well as the establishment of inducible latently infected cells. I do not address here the possibility that additional factors may compensate for suboptimal T cell receptor signaling. Interactions with antigen presenting cells would engage a number of costimulatory molecules and inhibitory receptors. In addition, the presence of inflammatory cytokines, such as would be expected during the acute stages of HIV-1 infection, may alter the level of cellular activation. Whether the ability of T cell stimulation to regulate HIV-1 is a matter of quality or simply quantity of signal should be examined further.

Having a library of CARs with a range of binding affinities allowed me to determine if HIV-1 responds to signaling in an analog fashion correlating with signal input or digitally regulated by specific thresholds resulting in all-or-none responses (Zikherman and Au-Yeung, 2015). Signaling through the CARs with affinities that were intermediate did not support active transcription despite a greater than 10-fold increase in binding affinity compared to the low affinity receptor. These results would suggest that TCR signaling provides more of an on/off switch and that there exist signaling thresholds that must be overcome to assure efficient transcription and replication.

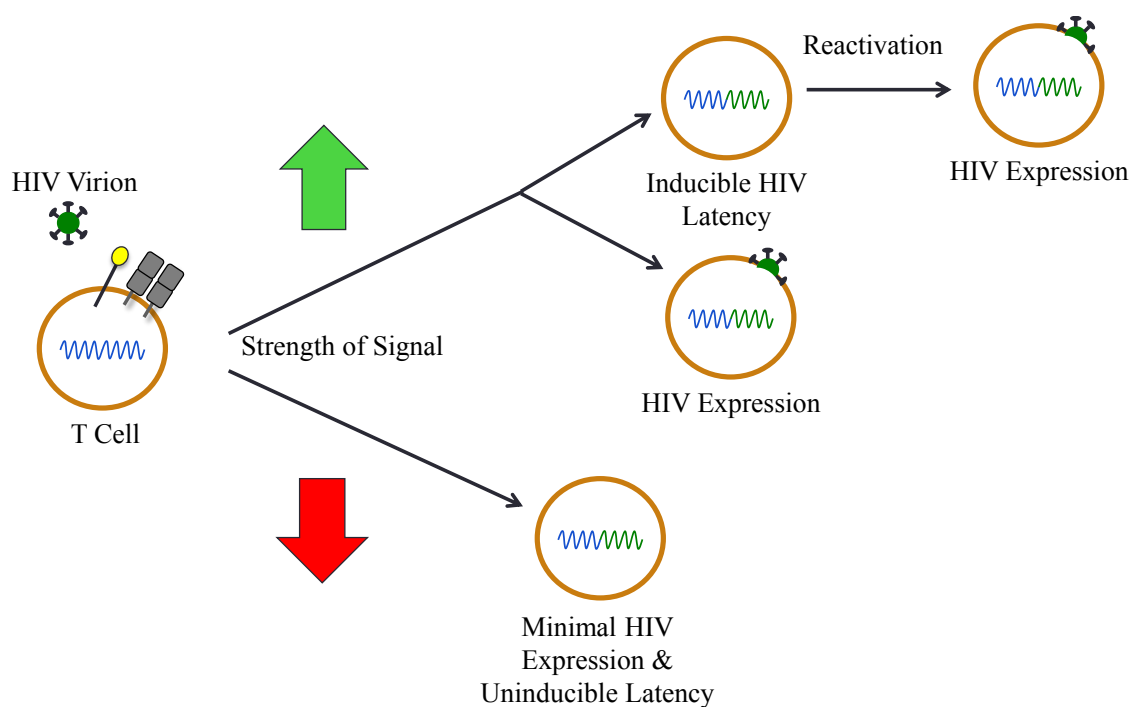
Signal transduction and gene expression are inherently noisy processes, and stochastic events are hypothesized to drive HIV-1 latency. That latency and HIV-1 replication are driven by episodic bursts of proviral transcription and Tat levels has been supported by mathematical modeling and experiments using engineered virus models (Burnett *et al.*, 2009; Donahue *et al.*, 2012; Razoooky *et al.*, 2015). Even if latency is

driven by random fluctuations of provirus transcription, T cell associated signals are strong modulators of noise, and targeting these pathways could enhance treatments directed at HIV-1 reactivation (Dar *et al.*, 2014). However, it is important to appreciate that although signaling and transcription are subject to stochastic variation, these are coordinated and combinatorial processes that lead to defined patterns of gene expression and phenotypic outcomes (Banos, Agelopoulos and Thanos, 2013).

Regulated aspects of transcription include assembly of multi-subunit complexes such as RNAPII and associated cofactors, chromatin, and transcription factors at the LTR. Figure 3.10 suggests that the association of NELF with RNAPII is regulated by TCR signaling. Multiple positive and negative signals are known to converge on NELF-driven transcriptional pausing. P-TEFb relieves NELF repression through phosphorylation (Fujinaga, *et al.*, 2004) and is itself regulated by cellular stress and signals (Garriga *et al.*, 1998; Zhou and Yik, 2006; Fujinaga *et al.*, 2015).

My data regarding the lack of histone acetylation as a block to transcriptional elongation at the time of viral integration is in marked contrast to its acknowledged role in the maintenance of HIV-1 latency in chronically infected cell lines and patient samples *ex vivo* (He and Margolis, 2002; Archin *et al.*, 2009). However, our lab has shown that NELF interacts with co-repressors including NCoR1-GPS2-HDAC3 at the HIV-1 promoter (Natarajan *et al.*, 2013) which may reinforce HIV-1 latency, especially during chronic infection, by facilitating post-translational modifications of histones and chromatin organization.

I propose that strength of signal at the time of infection acts as a bifurcating event leading to *either* robust transcription and the establishment of an inducible latent reservoir *or* minimal transcription and deep-seated latency (Illustration 3.1). My observations are consistent with the previous characterization of patient reservoirs that identified three subsets of latently infected cells: a small population of cells carrying inducible provirus, larger populations of cells with intact proviruses that are difficult to reactivate, and many defective proviruses (Ho *et al.*, 2013). Successful purging of the latent reservoir may require the use of a cocktail of latency reversing agents or the development of novel strategies to block reactivation (Xing and Siliciano, 2013; Darcis *et al.*, 2015; Darcis *et al.*, 2017).



**Illustration 3.1: T cell signaling during HIV-1 infection drives viral fate.** Amplitude of TCR signaling cascade polarizes cells towards a favorable environment for productive HIV-1 infection and the formation of a readily inducible latent reservoir or an unfavorable environment for viral replication marked by uninducible latency.

**CHAPTER FOUR: NUCLEASE-DEFICIENT CAS9-KRAB CAN BE USED TO  
SILENCE HIV-1 EXPRESSION THROUGH REDUCTION IN RNAPII  
INITIATION**

**INTRODUCTION**

*Discovery of CRISPR-Cas9 and Use as an HIV-1 Therapeutic*

CRISPR-Cas9 offers significant advantages over other strategies for gene editing. TALENs (transcription activator-like effector nucleases) and zinc finger nucleases were widely considered the most accurate molecular tools to target specific sections of the genome (Miller *et al.*, 2007; Mussolino *et al.*, 2011), but the application of a CRISPR-based approach heralded a new era in gene editing. In 2013, the laboratories of Feng Zhang and George Church simultaneously demonstrated that a Cas9 system adapted from *Streptococcus pyogenes* could be used for genome editing in both cell lines and induced pluripotent stem cells (Cong *et al.*, 2013; Mali *et al.*, 2013). Both approaches were based on the capacity of the bacterial CRISPR system to excise foreign DNA and insert it between the palindromic repeats in a region known as the protospacer. This protospacer is then cleaved, along with an adjoining portion of the palindrome, inserted into CRISPR Associated Protein 9, and recruited to its complementary sequence located within an invading pathogen (Mali, Esvelt and Church, 2013). It should also be pointed out that any corresponding DNA sequence must be immediately upstream from a Protospacer Adjacent Motif (PAM) site. The PAM specific sequence for Cas9 isolated from

*Staphylococcus aureus*, the bacterial species used for some of the experiments outlined in this chapter, is 5'-(N)NGRRT-3'. N refers to any nucleotide, while R denotes a purine base (Xie *et al.*, 2018).

By operating under these particular requirements, the exonuclease is directly targeted to a specific gene with minimal off-target effects (Kim *et al.*, 2015). By providing their own protospacer sequence in the form a small guide RNA (sgRNA), the Church and Zhang labs were able to redirect the CRISPR system to bind to and excise a human gene of interest.

An immediate application of CRISPR-based gene editing was its potential as an HIV-1 therapeutic. Since HIV-1 persists as transcriptionally silent latent proviruses, CRISPR provides a possible mechanism that could be used to excise integrated HIV-1. The Khalili lab first demonstrated the capacity of CRISPR to remove integrated proviruses through the use of guide RNAs directed towards the U3 region of the HIV-1 LTR (Hu *et al.*, 2014). However, significant questions still remain regarding method of delivery *in vivo*, off-target effects (which, although minimal, could still pose significant health concerns), complete removal of all latent proviruses, and viral escape (Fu *et al.*, 2013; Wang G *et al.*, 2016; Wang Z *et al.*, 2016; Mout *et al.*, 2017). The Khalili lab performed *in vivo* experiments using humanized mice infected with HIV-1, but failed to completely excise all HIV-1 DNA. In addition, significant targeting differences were seen between various tissue sites, with reduced efficacy in the central nervous system (Kaminski *et al.*, 2016).

For these reasons, I propose the use of a nuclease-deficient Cas9 to recruit chromatin-modifying factors to the HIV-1 provirus instead of degrading the genome. This approach provides the additional benefit of removing any immune pressure resulting in viral escape as in theory no transcription and thus no replication would occur at all. New efforts at the use of adeno-associated vectors as a delivery system could bypass the current issues with cellular penetrance and might allow the system I describe here to be brought into the clinic (Platt *et al.*, 2014).

#### *Cas9-KRAB Construct for Targeted Gene Repression*

The first attempts to fuse a nuclease-deficient Cas9 to a Krüppel Associated Box Domain was first described by the Wang and Gersbach labs in the mid-2010's (Lawhorn, Ferreira and Wang, 2014; Thakore *et al.*, 2015). KRAB domains are known to bind to the endogenous host factor, Kap1 or KRAB-Associated Protein-1, which together target various repressors to the region of the genome to which the KRAB domain is bound. These repressors include histone deacetylases, histone lysine-methyltransferases, and DNA methyltransferases. As a result, the surrounding genes become silenced, and we can detect both the spreading of marks associated with heterochromatin and a lack of transcription (Friedman *et al.*, 1996; Groner *et al.*, 2010; Oleksiewicz *et al.*, 2017). It is hypothesized that KRAB-Kap1 may mediate this transcriptional effect through directly dislodging the RNAPII complex (Moosmann *et al.*, 1997; Groner *et al.*, 2010).

Most KRAB-containing proteins have been described in mouse embryonic cells, such as the zinc-finger protein ZFP809 that can repress murine leukemia virus and

murine endogenous retroviruses (Wolf and Goff, 2009; Wolf *et al.*, 2015). The human KRAB-containing zinc-finger protein ZNF93 has recently been discovered as a restriction factor for the long interspersed nuclear element 1 or L1 in human embryonic stem cells (Jacobs *et al.*, 2014). KRAB-Kap 1 has consistently been shown to play an important role in cellular gene regulation and its adaptation to the CRISPR-Cas9 system offers a novel approach to targeted epigenetic editing.

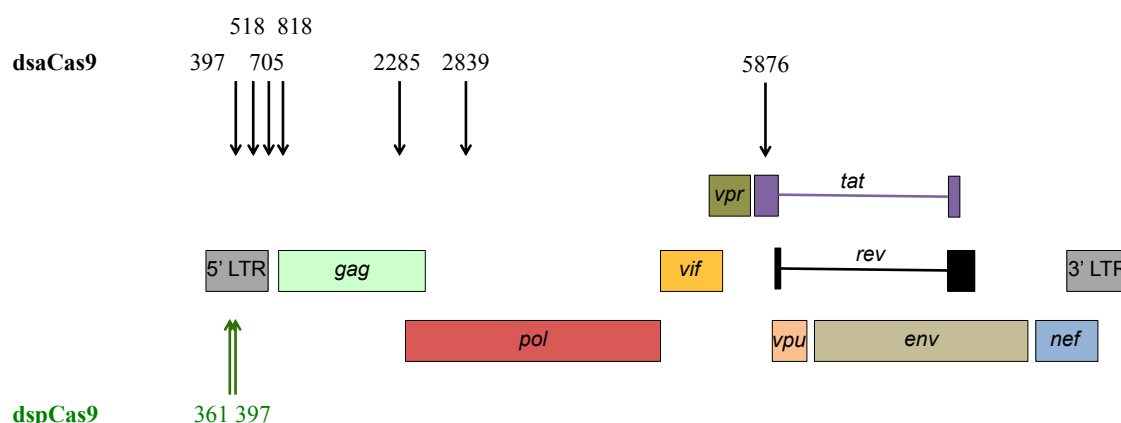
My goal was to introduce a nuclease-deficient Cas9-KRAB domain construct into cells at the time of infection with HIV-1. Together with sgRNAs directed against regions of the HIV-1 genome immediately upstream of the appropriate PAM site, our lab was able to successfully repress HIV-1 expression. We further illustrated the potential of this nuclease-deficient Cas9 system by electroporating it into latently infected T cells. The exonuclease was capable of preventing viral reactivation, highlighting its prospective role as an HIV-1 therapeutic. In this way, I aimed to bias an infection towards long-term transcriptional repression or inactivation.

## RESULTS

### *Nuclease-Deficient Cas9-KRAB Suppresses HIV-1 Expression*

I obtained nuclease-deficient Cas9-KRAB plasmids from the Wilson Wong laboratory at Boston University. They created two separate fusion constructs, one based on *Staphylococcus aureus* and a second on *Streptococcus pyogenes*. Although the dsCas9 is more specific due to its more stringent PAM sequence, dspCas9 is more

widely used and was the first variant isolated by the Church and Zhang labs. One sgRNA (dsp361) was modified from a sgRNA described in a paper using a dCas9 fused to an activating domain and overlaps the NF- $\kappa$ B sites in the HIV-1 LTR (Saayman *et al.*, 2016). A separate sgRNA (dsp397) binds to the SP1 site in the LTR (Hu *et al.*, 2014). Alex Olson, a technician in the Henderson lab who performed several of the experiments described in this chapter, identified a panel of dsaCas9 guide RNAs that would bind to the NL4-3 HIV-1 sequence using the online tool Benchling (Illustration 4.1) (Benchling, 2019). These sgRNAs span the proviral genome.

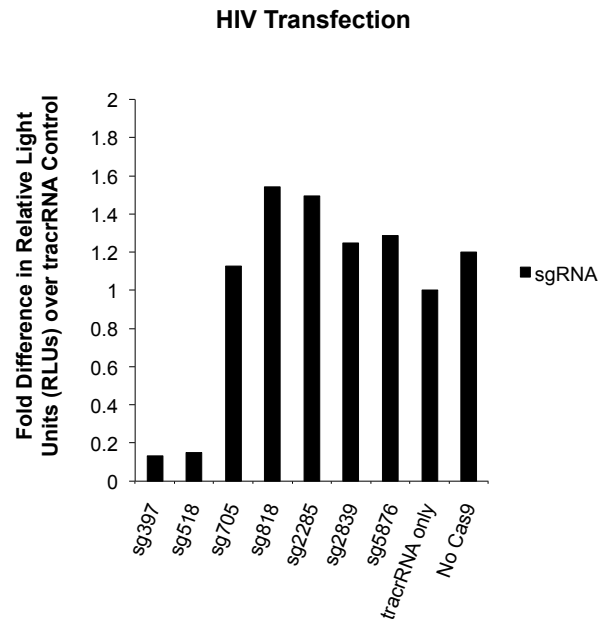


**Illustration 4.1: Selection of HIV-1 binding sgRNAs for CRISPR-mediated epigenetic silencing.** Binding sites were selected using the online tool Benchling that spanned the HIV-1 genome, including sites in the LTR, *gag-pol*, and *tat*. Schematic based off of a figure modified from (Colin and Van Lint, 2009).

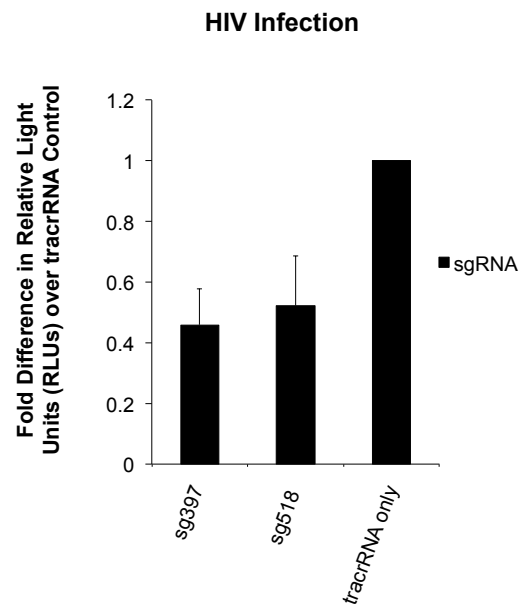
We first cotransfected the DNA sequences encoding for the dsaCas9 sgRNAs with NL4-3.Luc, a single-cycle luciferase construct, into HEK293T cells and measured luciferase at 48 hours post transfection. Both dsa397 and dsa518, located within the HIV-1 LTR, showed the greatest effect on luciferase repression and we focused primarily on

these guides (Figure 4.1A). We further illustrated the potential of this system to block HIV-1 expression by infecting HEK293T cells with VSV-G pseudotyped NL4-3.Luc while transfecting with dsaCas9. Twenty-four hours later, we transfected cells with plasmids encoding for the sgRNAs and measured luciferase units three days post-infection. We were able to block at least 50% of viral transcription resulting from HIV-1 infection (Figure 4.1B).

A



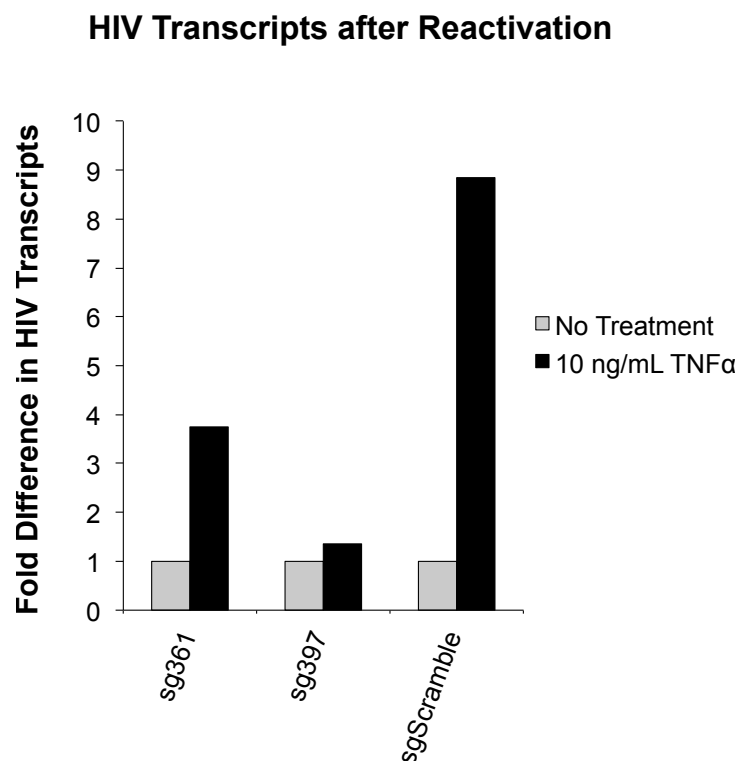
B



**Figure 4.1: KRAB binding to the HIV-1 LTR inhibits viral expression.** (A) HEK293T cells were co-transfected with VSV-G NL4-3.Luc, dsaCas9-KRAB, and the indicated sgRNA. 48 h later, cells were lysed for luciferase analysis. Data are presented as fold difference in RLU over tracrRNA only control. (B) HEK293T cells were infected with VSV-G NL4-3.Luc and simultaneously transfected with dsaCas9-KRAB. 24 h later, cells were transfected with the indicated sgRNA. 48 h post infection, cells were lysed for luciferase analysis. Data are presented as fold difference in RLU over “tracrRNA only” control and represent mean  $\pm$  standard deviation. Data in B was performed in triplicate. “tracrRNA only” refers to the addition of the sequence corresponding to the tracrRNA without the crRNA sequence necessary to bind HIV-1. “No Cas9” refers to HIV-1 transfection only.

### *Nuclease-Deficient Cas9-KRAB Prevents Latent HIV-1 Reactivation*

J-Lat cells harbor an integrated latent copy of HIV-1 that is responsive to various Tat inducers including TNF- $\alpha$  and phorbol esters (Jordan, Bisgrove and Verdin, 2003; Williams *et al.*, 2007). We thus sought to determine if we could block HIV-1 reactivation in these cells through the use of our nuclease-deficient Cas9 construct. Because J-Lat cells are not easily transfected with plasmids, we used our dspCas9 system, for which we had RNA transcripts of our sgRNAs. Following transduction of the J-Lats with dspCas9 expressed in a lentiviral vector, cells with the exonuclease were enriched through the use of an antibiotic selection marker. We then electroporated the J-Lats with either of the sgRNAs for the *Streptococcus pyogenes* construct. Five days post electroporation, cells were restimulated using TNF- $\alpha$ . Although treatment with the LRA resulted in a baseline 9-fold increase in HIV-1 RNA as measured by qRT-PCR, this was reduced by more than 50% in the samples treated with the sgRNAs (Figure 4.2).



**Figure 4.2: KRAB-Kap1 blocks HIV-1 latency reversal in J-Lat cells.** J-Lat cells were transduced with a dCas9-KRAB plasmid within a selection vector. Cells were electroporated with sgRNAs indicated above and reactivated with 10 ng/mL TNF $\alpha$  five days post-electroporation. HIV-1 transcription was measured by qRT-PCR using *gag*-specific primers 24 h after stimulation. Values are shown as fold difference in HIV-1 RNA transcripts over corresponding non-reactivated controls. “sgScramble” refers to the selection of a sgRNA not known to bind to any predicted sequence in the human genome.

## DISCUSSION

The use of latency-reversing agents to reactivate transcriptionally silent HIV-1 has so far been unable to eradicate the DNA reservoir in any clinical trial. In fact, most HDACi's have failed to result in any detectable reduction in proviral load (Sagot-Lerolle *et al.*, 2008; Archin *et al.*, 2010; Archin *et al.*, 2012). Efforts to permanently suppress

HIV-1 or to bias an infection during the early stages towards latency must be considered as potential therapeutics.

The most challenging aspect to permanent HIV-1 suppression is our ability to specifically target transcriptional host repressors to the provirus. CRISPR-based gene editing provides a substantial improvement over previous strategies, due to the specificity of its binding and the lack of off-target effects. However, the possibility of viral escape poses a major barrier to its successful use as a nuclease. I propose its adaptation, however, to a delivery system in which it can be used to bring binding partners, such as a KRAB domain, to the proviral genome. Other labs have used a nuclease-deficient Cas9 to deliver an activating domain to the HIV-1 LTR (Zhang *et al.*, 2015; Saayman *et al.*, 2016). While this approach seems feasible, the data presented in Chapter 3 illustrates the challenges at reversing latency once established. Host repressors recruit other transcription factors, which in turn target larger complexes such as HDACs, histone methyltransferases, and polymerase-binding factors such as NELF. In concert with one another, large transcriptional networks and scaffolds are formed, resulting in entrenched heterochromatin (Ivanov *et al.*, 2007; Natarajan *et al.*, 2013; Meier and Brehm, 2014). For instance, evidence exists that Kap1 may operate in conjunction with the newly discovered HUSH complex to silence endogenous retroviral elements in mouse embryonic stem cells (Robbez-Masson *et al.*, 2018). HUSH, or the human silencing hub, has been identified as a restriction factor for HIV-1 and HIV-2 expression and is targeted for ubiquitination by the HIV-2 protein Vpx or Viral Protein X (Chougui *et al.*, 2018;

Yurkovetskiy *et al.*, 2018). Future work will need to be performed to determine if HUSH and Kap1 interact directly or indirectly.

The existence of multiple layers of repressive factors that cooperate to silence HIV-1 expression suggests that the reverse strategy of “block and lock” may be viable (Darcis, Van Driessche and Van Lint, 2017). If we can bias latency towards a specific fate, we may be able to achieve a functional cure through intrinsic entrenchment of this repression. My data indicated that guide RNAs directed specifically against the HIV-1 LTR inhibit viral expression. These guides enabled us to suppress HIV-1 transcription shortly after infection and achieve a more than 50% block to latency reversal in chronically infected cells. The differences in efficacy of different guide RNAs indicate that a cocktail of multiple guides may be necessary to repress viral transcription beyond a point where a patient can interrupt therapy. It is not surprising that the most effective guides overlap with specific binding sites in the HIV-1 LTR, perhaps indicating a dual role of KRAB-Kap1 recruitment and a direct steric hindrance to transcription factor binding.

A major challenge to bringing this approach into clinical trials is the method of cellular delivery. However, multiple labs have seen success with adenovirus-based vectors, and I believe that an approach like this may be reasonable (Platt *et al.*, 2014; Kaminski *et al.*, 2016). Because the system described here does not result in gene deletion, I hypothesize that any of the already rare off-target effects will be minimal and that this strategy poses no risk of hereditary gene editing.

## CHAPTER FIVE: DISCUSSION AND FUTURE IMPLICATIONS

### Summary of Results

The results described within this dissertation highlight the importance of the cellular and local chromatin environments at the time of HIV-1 infection on the fate of the virus. They also enabled me to verify the hypotheses detailed within the Specific Aims that were listed in the first chapter. For Specific Aim 1, I determined the effect of distinct T cell receptor signal strengths at the time of HIV-1 infection on viral expression within primary cells and reactivation of latent proviruses. To study this, I manipulated the cellular activation state through the use of chimeric antigen receptors that mimicked the endogenous T cell receptor. Through the substitution of single chain variable fragments differing in antigen binding affinity, I modulated the strength of signal that a cell received at the time of viral infection. These CARs intersected the native T cell receptor signaling pathways, as demonstrated by similar global transcriptional changes (Figure 3.2) and increased CD69 expression (Figure 3.3). Further evidence of their effects can be seen via the differences observed in acute HIV-1 expression.

Stimulation of CAR-expressing cells with their cognate Her2 antigen resulted in an increase in viral expression, and this response correlated with the strength of cellular activation (Figure 3.5). However, I detected no similar increase in viral integration, implying that the observed effects were due to post-integration events. I further confirmed these results by direct measurement of RNA transcripts and saw a similar pattern as observed with the luciferase analysis (Figure 3.7).

It was reasonable to assume that cells which expressed higher levels of HIV-1 at early time points would be less likely to also harbor inducible latent proviruses since the total number of integrated proviruses was held constant. However, cells that received the greatest amount of stimulation during viral infection were also the most responsive to latency-reversing agents predicted to activate HIV-1 transcription through different biochemical pathways (Figure 3.9).

To address Specific Aim 2, for which I analyzed the transcriptional landscape of the provirus among cell receiving differential stimulation at the time of HIV-1 infection, I performed chromatin immunoprecipitation. I discovered that the local chromatin environment was open and accessible as measured by histone acetylation regardless of cellular activation. This is in agreement with multiple other studies that revealed a bias towards open chromatin that can be attenuated if host factors involved in nuclear import are knocked out or their interactions with HIV-1 capsid are blocked (Wang *et al.*, 2007; Koh *et al.*, 2013; Sowd *et al.*, 2016). The data in Figure 3.10 indicated that successful polymerase processivity only occurred under high activation conditions in concert with release of the pausing factor NELF from the HIV-1 LTR. Based on this evidence, I concluded that although HIV-1 preferentially integrates into regions of open chromatin, the level of global cellular activation regulates whether host repressors are recruited to the provirus. The lack of responsiveness of the virus within minimally activated cells to secondary stimulation suggests that early association with host repressors results in entrenched transcriptional repression and deep-seated latency.

These results led me to hypothesize that I could bias an infection towards deep-seated latency, which was the basis for Specific Aim 3. I hypothesized that I could use a nuclease-deficient Cas9 construct to recruit host repressors to the provirus and suppress HIV-1 expression. By fusing dCas9 to a KRAB domain, we were able to substantially block HIV-1 expression upon transfection with an HIV-1 plasmid and achieved a greater than 50% reduction in viral protein production after infection (Figure 4.1B). In order to determine whether KRAB-Kap1 could induce permanent repression, we electroporated a J-Lat line bearing both a silent copy of HIV-1 along with a nuclease-deficient Cas9 construct with LTR-specific sgRNAs. Treatment of these cells with TNF- $\alpha$  was not sufficient to achieve substantial viral reactivation as it did in the control condition, in which there was a 9-fold increase in viral protein production (Figure 4.2). This experiments listed here confirm my central hypothesis that the global cellular environment at the time of HIV-1 infection determines the potential for inducible latent infection and that this axis can be bypassed by modification of the local chromatin environment.

### **Latency: A Goal or an Obstacle?**

Based on the data detailed in this defense as well as the failure of multiple clinical trials to clear the entire viral reservoir, I propose that a functional cure of HIV-1 cannot be achieved through latency reversal. There is growing evidence that the latent reservoir is not homogenous, but rather a collection of multiple subsets in which latency is both

regulated by different mechanisms and has differing capacities to be re-activated. I have illustrated here that the level of cellular activation at the time of infection may determine whether latently infected cells are inducible or non-inducible. It has been known for some time that significant portions of the viral reservoir are refractory to standard LRAs in spite of their intact genomic content (Ho *et al.*, 2013; Hosmane *et al.*, 2017). I have argued in this dissertation that the cellular conditions at the time of viral entry determine the long-term fate of the virus and their susceptibility to LRAs. Minimal levels of stimulation, which may be sufficient for viral entry and integration, are inadequate to recruit an activating transcriptional network at the time of infection or to remove a repressive network during secondary stimulation.

The existence of these multiple subsets also calls into question the accepted paradigm of chromatin in establishment of latency. Exactly why I did not detect any changes in histone acetylation are not clear, but my data suggests that initial proviral repression may recruit other host factors, resulting in an entrenched network of chromatin-modifying factors and other repressive complexes. Histone acetylation, then, may be a marker for specific subsets of latently infected cells and not the entire reservoir.

This may explain the discrepancy between the importance of histone acetylation in cell line models and the complete absence of any evidence that histone deacetylase inhibitors can perturb the viral reservoir *in vivo*. However, evidence exists that a cocktail of LRAs including HDACi's result in greater viral reactivation than a single drug, perhaps through interruption of multiple arms of whatever repressive transcriptional network eventually maintains a silent provirus in its latent state.

Regardless, no clinical drug may be capable of clearing the entire viral reservoir. Instead, based on my data indicating that multiple forms of latency exist, I propose that a functional cure may be achieved through treatments that bias infected cells towards deep-seated latency. Virus integrated into cells with the low-affinity chimeric antigen receptors was not easily responsive to PMA or antibodies against the endogenous CD3 and CD28 receptors, which are significantly stronger than any cocktail which may be brought into clinic. It is reasonable to assume then that no biological effect may achieve a greater level of stimulation either. Antigen presentation in the context of an antigen-presenting cell may provide multiple signals but it is unlikely that this interaction would persist for a full day, as in an *in vitro* anti-CD3/CD28 condition. These infected cells then might pose no direct harm to the host, although they may re-seed the latent reservoir through clonal proliferation.

### **Remaining Mechanistic Questions**

My work does not address all suggested mechanisms that contribute to latency such as host integration site, proviral genomic integrity, and transcriptional interference from neighboring genes. Regarding polymerase interference, evidence from our lab has shown that RNAPII read-through from the host promoter contributes little to HIV-1 transcriptional regulation. Through analysis of multiple cell lines with integrated proviruses in differing orientation to the host gene, no differences could be detected in latency reversal (Kaczmarek Michaels *et al.*, 2015). However, binding of NELF appeared

to be the primary regulatory factor in all conditions, in agreement with the evidence presented in Chapter Three. Future work on this project should consist of genomic sequencing to determine if I am polarizing integration sites towards or away from heterochromatic regions under low activation conditions and further PCR analysis to verify the integration of the viral genome, similar to that outlined by the Siliciano group (Bruner *et al.*, 2016).

### **The Impact of TCR Signaling on T Cell Function and Differentiation**

In an effort to verify that signaling through the chimeric antigen receptors recapitulated endogenous TCR signaling cascades, I analyzed the phenotypes of differentially stimulated CD4<sup>+</sup> T cells in multiple experiments including a microarray and flow analysis of surface markers. In addition to validating the CAR system, these assays raise a number of intriguing questions regarding the impact of signal strength on T cell function. As can be seen in the microarray analysis in Figure 3.2, multiple genes are immediately induced or repressed upon the slightest level of cellular stimulation. These genes, including the transcription factor KLF10, appear to require a low signaling threshold in order to become expressed. Other genes, including IL2, are transcribed in a gradient fashion and directly correlated to the level of upstream activation. Finally, a subset of genes exists, including FOXP3, a differentiation marker for Tregs (Allan *et al.*, 2005), that is induced by robust signaling, only achieved through engagement of the endogenous receptor (Table 3.1).

Instead of the creation of distinct T cell subsets in which all cells that express the same surface antigens have similar gene profiles, our data suggest that there may be a functional spectrum regardless of T cell phenotype. A range of transcriptional activity can exist within the same cell subsets due to varying signaling thresholds that may or may not have been reached. TCR stimulation uniformly results in an expansion of the CCR7<sup>+</sup> CD45RA<sup>-</sup> population (Figure 3.4), often indicative of central memory cells (Okada *et al.*, 2008). However, the expression of most gene transcripts in Figure 3.2 are distinctly different between cells stimulated through the low affinity CAR and those activated by antibodies to CD3 and CD28. The impact of signaling on T cell cytokine production, further differentiation, and other functional outcomes within these memory populations may be considerable.

Some of the genes most differentially regulated upon TCR stimulation in Figure 3.2 and Table A.1 (see Appendix) are those involved in either DNA replication, such as the nuclease RNASEH1 and the replication protein RPA3, or metabolism, including the glycolysis enzymes ENO1 and PGK1. The metabolic profiles of T cell subsets and their role within the immune response are of significant interest. For instance, a recent study identified glycolysis-related gene networks as critical to the capacity of T<sub>h</sub>17 cells to differentiate into T<sub>h</sub>1 cells (Karmaus *et al.*, 2019). Further, it has been shown that the capacity of the host cell to conduct glycolysis is a key regulator of HIV-1 replication (Hegedus, Kavanagh Williamson and Huthoff, 2014) and may itself be increased upon viral infection (Hollenbaugh, Munger and Kim, 2011). My experiments highlight the importance of T cell signaling on both HIV-1 replication and cellular differentiation.

## Study Limitations

While the research contained within this dissertation highlights several key mechanisms which regulate latent HIV-1, the findings presented here are in no way intended to be a complete summary of all factors which bias the balance between inducible and non-inducible latent reservoirs. I have thoroughly discussed the impact of signal amplitude on HIV-1 expression, but I have not analyzed signal quality. Future experiments within the Henderson lab will include the mutations of key residues within the CD28 and CD3 $\zeta$  signaling domains of the chimeric antigen receptors in order to determine which residues and more importantly which signaling cascades are critical for the increase in HIV-1 expression that is observed upon TCR engagement.

In addition, work done by a fellow graduate student, Kyle Pedro, has indicated that HIV-1 infections in the context of an immunological synapse between a CD4<sup>+</sup> T cell and a dendritic cell can compensate for suboptimal signaling within the target cell. The exact nature of these compensatory signals, and if inhibitory signals from receptors such as CTLA-4, PD-1, and Tim-3 also modulate the TCR-HIV axis, is not explored here.

I have also not described the nature of timing on HIV-1 infection. It is known that T cell activation prior to viral entry facilitates robust HIV-1 replication; however, the role of weak T cell signaling at this time point has not been fully examined. Minimal cellular activation prior to HIV-1 fusion with the cell membrane may allow for the expression of necessary entry receptors without providing an optimal environment for reverse transcription of the viral RNA genome or transcription of the integrated provirus. For

instance, the Lewin model of HIV-1 latency manipulates cells via treatment with CCL19 and CCL21, which renders them susceptible to HIV-1 integration but is not sufficient for subsequent transcription (Saleh *et al.*, 2007). The fact that the CCL19 receptor CCR7 regulates HIV-1 integration via NF- $\kappa$ B induction (Saleh *et al.*, 2016), but that this is inadequate for NF- $\kappa$ B - mediated transcription, provides more evidence for our conclusions regarding the existence of signaling thresholds that control HIV-1 expression. In contrast to the effects of CCR7 ligands, culturing CD4<sup>+</sup> T cells with IL-7 prior to infection has been shown to provide the necessary stimulation for efficient HIV-1 replication (Steffens *et al.*, 2002), while IL-27 restricts HIV-1 expression in PBMCs (Fakruddin *et al.*, 2007). The level of cellular activation prior to viral entry, and the exact quantity and quality of signaling cascades involved, should be explored in further studies.

My experiments focused on the impact of T cell receptor signaling at the time of infection on HIV-1 expression and latency reversal and revealed that this effect persisted for at least one week. However, latency in the context of a HIV<sup>+</sup> individual may persist for the entire lifespan of an infected cell. With further optimization of our tunable model to extend the time of survival of CAR<sup>+</sup> primary CD4<sup>+</sup> T cells after HIV-1 infection, the Henderson lab will be able to address questions about the dynamics of latency reversal.

In addition, I have not discussed the mechanisms that contribute to HIV-1 latency in other cellular reservoirs. In Chapter One, I discussed the contributions of  $\gamma\delta$  T cells and macrophages to HIV-1 persistence. Although evidence exists that establishment and maintenance of HIV-1 latency may require cell-specific factors, I do not address that here. For instance, HIV-1 inhibits apoptosis within infected macrophages by upregulating

the cell survival receptor TREM-1 or Triggering receptor expressed on myeloid cells-1 (Yuan *et al.*, 2017). This is a cell-specific mechanism, which relies upon signals downstream from TREM-1 to establish latency. The Cannon lab also identified the CoREST complex (Corepressor to RE1 silencing transcription factor) as a microglia-specific inhibitor of HIV-1 transcription in humanized mice. Because this is a unique mechanism for silencing of HIV-1 expression, microglia cells are especially responsive to LRAs that disrupt the CoREST complex (Llewellyn *et al.*, 2018). However, my experiments highlight the establishment of HIV-1 latency in CD4+ T cells and the LRAs that may disrupt viral repression in those cells. Future cure efforts will require both the manipulation of the balance between inducible and non-inducible latent CD4+ T cell subsets as well as strategies to target HIV-1 persistence in other cell types.

In regards to the use of nuclease-deficient Cas9-KRAB, I have only presented preliminary data here. I have not described a method of delivery or analyzed any off-target effects. Our lab is currently conducting experiments using multiple forms of latency reversing agents, and our eventual goal is to examine KRAB-Kap1 repression of HIV-1 in primary CD4+ T cells. KRAB-Kap1 is a promising complex for manipulating HIV-1 proviral expression. If we can better understand the function of other cellular host factors, additional key transcription factors might be utilized in a cell-specific manner.

## Clinical Implications

A functional cure of HIV-1 would have profound benefits to those living with HIV/AIDS. In spite of all of the progress obtained since the height of the epidemic in the 1980's, a significant portion of the population remains at risk of contracting HIV-1 and living with lifelong immune dysfunction. Challenges at producing a broad-spectrum vaccine or at achieving a clinically viable cure using gene excision remain daunting. Instead, a functional cure, in which a patient can cease antiretroviral therapy for years or decades with only occasional follow-up, represents the gold standard of HIV-1 therapy going forward.

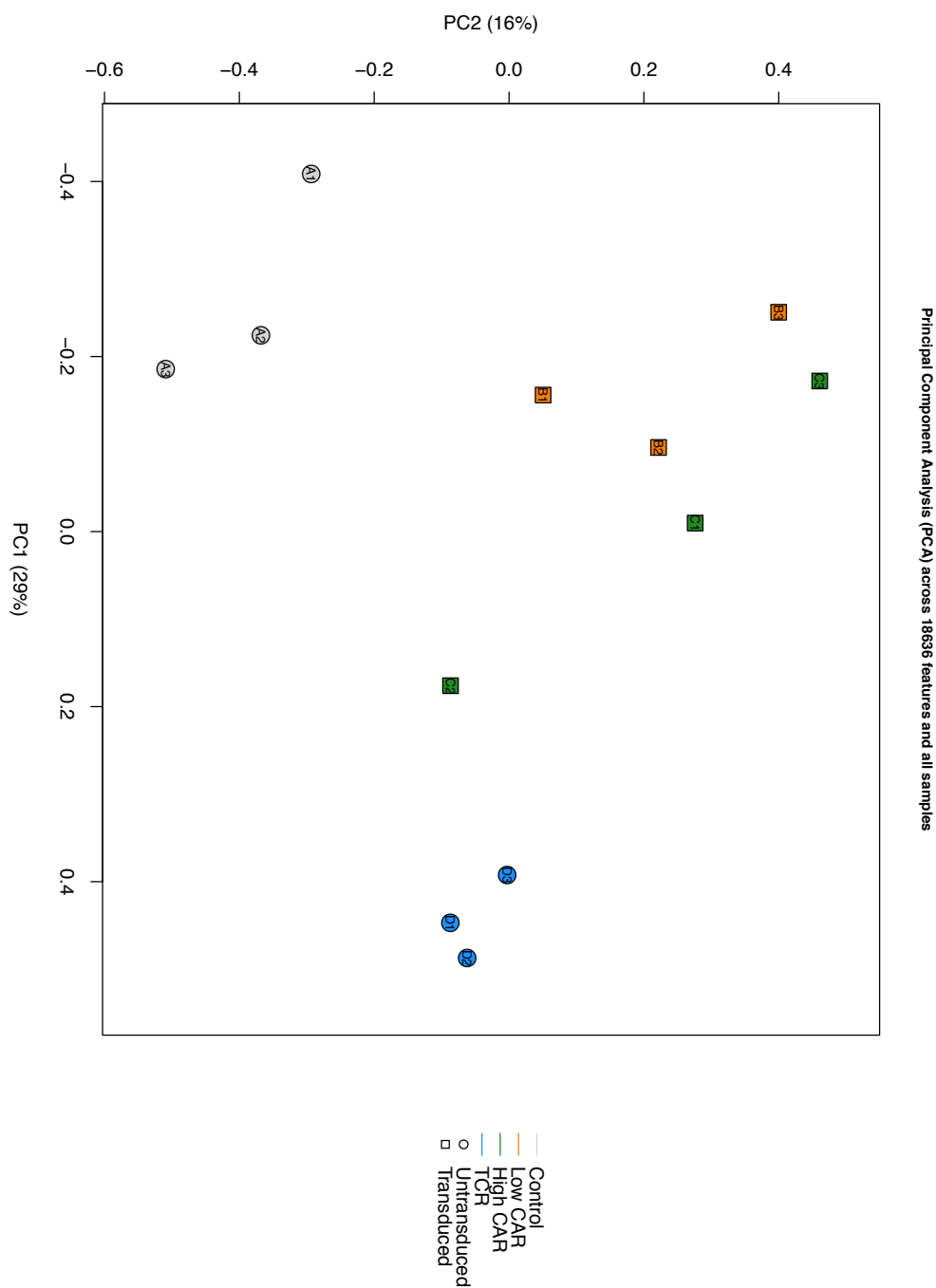
The existence of at least two latent reservoirs, one which is readily inducible to the strongest LRAs *ex vivo* and one which remains refractory to stimulation after multiple challenges (Hosmane *et al.*, 2017), suggests that a complete reversal of all potentially inducible latent proviruses may not be feasible. Instead, I present here the possibility of achieving permanent epigenetic silencing of all integrated HIV-1. Since cellular mechanisms that are recruited at the time of infection have long-term consequences on viral fate, there may be a therapeutic window in which to bias the balance between these two latent populations. My work also suggests that a two-step approach may be required: a cocktail of LRAs taken shortly after infection to remove the most easily reversible proviruses and then a gene editing based technique to further suppress all remaining infections into a deep-seated latency.

The viral reservoir after years of suppressive therapy will not resemble the original population of infected cells. Differences in clonal proliferation and changes to epigenetic marks may alter the chromatin environment so that it no longer mimics the layers of repression observed in the original infected ancestor cells (Zerihun *et al.*, 2015; Wang *et al.*, 2018). However, the ability of KRAB-Kap1 mediated repression to persist despite cellular division (Ayyanathan *et al.*, 2003) suggests that some of the epigenetic changes which occur during a new round of viral infection today may dictate the nature and dynamics of the latent reservoir for the remaining decades of a patient's life. While this poses serious challenges, the research conducted for this dissertation suggests that we may also be able to shape the future latent reservoir in a beneficial manner for the patient.

**APPENDIX: MICROARRAY ANALYSIS OF DIFFERENTIALLY STIMULATED  
CD4+ T CELLS IN CHAPTER THREE**

**Principal Component Analysis**

Principal component analysis was performed on the genes listed as significantly different from the baseline unstimulated CD4+ T cell condition in the microarray shown for Figure 3.2. The separation of samples by treatment along the PC1 axis explains 29% of all variance, while PC2 explains 16% of all variance (Figure A.1). Clear clustering can be seen between all experimental conditions, with the low and high affinity CAR-expressing cells appearing intermediate between the unstimulated and TCR-stimulated groups.



**Figure A.1: Magnitude of T cell signaling differentially regulates genes in a gradient fashion.**

Signaling from the low affinity and high affinity CAR display an intermediate phenotype between that of the unstimulated and TCR-stimulated conditions. Principal component analysis was performed on all genes listed as significantly differentially expressed between conditions. The percentage of variance across all conditions explained by each principal component axis is listed as a percentage. See also Figure 3.2.

## Microarray Analysis

All genes shown in the microarray in Figure 3.2, each of which has a one-way Anova FDR-corrected  $q$  value of less than 0.01. Each gene is listed along with its Human Entrez Gene ID, accepted description, and cluster number.

**Table A.1: List of genes whose expression is significantly altered upon TCR stimulation.** All genes from the microarray listed in Figure 3.2 are described in the following pages. Genes were arbitrarily assigned to clusters based on gene expression patterns.

Human Entrez Gene ID(s)	Symbol	Description	Cluster
<a href="#">10952</a>	SEC61B	Sec61 translocon beta subunit	1
<a href="#">51114</a>	ZDHHC9	zinc finger DHHC-type containing 9	1
<a href="#">115098</a>	CCDC124	coiled-coil domain containing 124	1
<a href="#">64118</a>	DUS1L	dihydrouridine synthase 1 like	1
<a href="#">79644</a>	SRD5A3	steroid 5 alpha-reductase 3	1
<a href="#">9643</a>	MORF4L2	mortality factor 4 like 2	1
<a href="#">1802</a>	DPH2	DPH2 homolog	1
<a href="#">150223</a>	YDJC	YdjC homolog (bacterial)	1
<a href="#">54998</a>	AURKAIP1	aurora kinase A interacting protein 1	1
<a href="#">7277</a>	TUBA4A	tubulin alpha 4a	1
<a href="#">55004</a>	LAMTOR1	late endosomal/lysosomal adaptor, MAPK and MTOR activator 1	1
<a href="#">8321</a>	FZD1	frizzled class receptor 1	1
<a href="#">4074</a>	M6PR	mannose-6-phosphate receptor, cation dependent	1
<a href="#">2720</a>	GLB1	galactosidase beta 1	1
<a href="#">7469</a>	NELFA	negative elongation factor complex member A	1
<a href="#">60496</a>	AASDHPPT	aminoadipate-semialdehyde dehydrogenase-phosphopantetheinyl transferase	1
<a href="#">5479</a>	PPIB	peptidylprolyl isomerase B	1
<a href="#">84337</a>	ELOF1	elongation factor 1 homolog	1
<a href="#">27314</a>	RAB30	RAB30, member RAS oncogene family	1
<a href="#">27247</a>	NFU1	NFU1 iron-sulfur cluster scaffold	1
<a href="#">157922</a>	CAMSAP1	calmodulin regulated spectrin associated protein 1	1
<a href="#">51629</a>	SLC25A39	solute carrier family 25 member 39	1
<a href="#">64769</a>	MEAF6	MYST/Esa1 associated factor 6	1
<a href="#">29081</a>	METTL5	methyltransferase like 5	1
<a href="#">58527</a>	ABRACL	ABRA C-terminal like	1
<a href="#">11315</a>	PARK7	Parkinsonism associated deglycase	1
<a href="#">1233</a>	CCR4	C-C motif chemokine receptor 4	1
<a href="#">4726</a>	NDUFS6	NADH:ubiquinone oxidoreductase subunit S6	1
<a href="#">6346</a>	CCL1	C-C motif chemokine ligand 1	1
<a href="#">28974</a>	C19orf53	chromosome 19 open reading frame 53	1
<a href="#">10286</a>	BCAS2	breast carcinoma amplified sequence 2	1
<a href="#">5133</a>	PDCD1	programmed cell death 1	1
<a href="#">6846</a>	XCL2	X-C motif chemokine ligand 2	1
<a href="#">6375</a>	XCL1	X-C motif chemokine ligand 1	1
<a href="#">11043</a>	MID2	midline 2	1
<a href="#">83443</a>	SF3B5	splicing factor 3b subunit 5	1
<a href="#">9764</a>	KIAA0513	KIAA0513	1
<a href="#">4697</a>	NDUFA4	NDUFA4, mitochondrial complex associated	1
<a href="#">55852</a>	TEX2	testis expressed 2	1
<a href="#">5777</a>	PTPN6	protein tyrosine phosphatase, non-receptor type 6	1
<a href="#">5325</a>	PLAGL1	PLAG1 like zinc finger 1	1
<a href="#">928</a>	CD9	CD9 molecule	1
<a href="#">10897</a>	YIF1A	Yip1 interacting factor homolog A, membrane trafficking protein	1

<a href="#">26090</a>	ABHD12	abhydrolase domain containing 12	1
<a href="#">89927</a>	C16orf45	chromosome 16 open reading frame 45	1
<a href="#">8600</a>	TNFSF11	tumor necrosis factor superfamily member 11	1
<a href="#">3394</a>	IRF8	interferon regulatory factor 8	1
<a href="#">5606</a>	MAP2K3	mitogen-activated protein kinase kinase 3	1
<a href="#">2539</a>	G6PD	glucose-6-phosphate dehydrogenase	1
<a href="#">7074</a>	TIAM1	T-cell lymphoma invasion and metastasis 1	1
<a href="#">518</a>	ATP5G3	ATP synthase, H+ transporting, mitochondrial Fo complex subunit C3 (subunit 9)	1
<a href="#">3732</a>	CD82	CD82 molecule	1
<a href="#">619279</a>	ZNF704	zinc finger protein 704	1
<a href="#">51406</a>	NOL7	nucleolar protein 7	1
<a href="#">6500</a>	SKP1	S-phase kinase associated protein 1	1
<a href="#">1020</a>	CDK5	cyclin dependent kinase 5	1
<a href="#">2787</a>	GNG5	G protein subunit gamma 5	1
<a href="#">91582</a>	RPS19BP1	ribosomal protein S19 binding protein 1	1
<a href="#">200894</a>	ARL13B	ADP ribosylation factor like GTPase 13B	1
<a href="#">6367</a>	CCL22	C-C motif chemokine ligand 22	1
<a href="#">55630</a>	SLC39A4	solute carrier family 39 member 4	1
<a href="#">3682</a>	ITGAE	integrin subunit alpha E	1
<a href="#">2589</a>	GALNT1	polypeptide N-acetylgalactosaminyltransferase 1	1
<a href="#">22906</a>	TRAK1	trafficking kinesin protein 1	1
<a href="#">9562</a>	MINPP1	multiple inositol-polyphosphate phosphatase 1	1
<a href="#">5875</a>	RABGGTA	Rab geranylgeranyltransferase alpha subunit	1
<a href="#">2182</a>	ACSL4	acyl-CoA synthetase long-chain family member 4	1
<a href="#">5997</a>	RGS2	regulator of G-protein signaling 2	1
<a href="#">5066</a>	PAM	peptidylglycine alpha-amidating monooxygenase	1
<a href="#">51096</a>	UTP18	UTP18, small subunit processome component	1
<a href="#">51726</a>	DNAJB11	DnaJ heat shock protein family (Hsp40) member B11	1
<a href="#">3320</a>	HSP90AA1	heat shock protein 90 alpha family class A member 1	1
<a href="#">54438</a>	GFOD1	glucose-fructose oxidoreductase domain containing 1	1
<a href="#">5569</a>	PKIA	protein kinase (cAMP-dependent, catalytic) inhibitor alpha	1
<a href="#">90441</a>	ZNF622	zinc finger protein 622	1
<a href="#">7133</a>	TNFRSF1B	TNF receptor superfamily member 1B	1
<a href="#">27333</a>	GOLIM4	golgi integral membrane protein 4	1
<a href="#">134637</a>	ADAT2	adenosine deaminase, tRNA specific 2	1
<a href="#">7150</a>	TOP1	topoisomerase (DNA) I	1
<a href="#">10915</a>	TCERG1	transcription elongation regulator 1	1
<a href="#">811</a>	CALR	calreticulin	1
<a href="#">8425</a>	LTBP4	latent transforming growth factor beta binding protein 4	1
<a href="#">5450</a>	POU2AF1	POU class 2 associating factor 1	1
<a href="#">56253</a>	CRTAM	cytotoxic and regulatory T-cell molecule	1
<a href="#">23305</a>	ACSL6	acyl-CoA synthetase long-chain family member 6	1
<a href="#">57472</a>	CNOT6	CCR4-NOT transcription complex subunit 6	1
<a href="#">58526</a>	MID1IP1	MID1 interacting protein 1	1
<a href="#">11057</a>	ABHD2	abhydrolase domain containing 2	1
<a href="#">25822</a>	DNAJB5	DnaJ heat shock protein family (Hsp40) member B5	1
<a href="#">9882</a>	TBC1D4	TBC1 domain family member 4	1
<a href="#">58493</a>	INIP	INTS3 and NABP interacting protein	1
<a href="#">4023</a>	LPL	lipoprotein lipase	1
<a href="#">79929</a>	MAP6D1	MAP6 domain containing 1	1
<a href="#">3904</a>	LAIR2	leukocyte associated immunoglobulin like receptor 2	1
<a href="#">11098</a>	PRSS23	protease, serine 23	1
<a href="#">23012</a>	STK38L	serine/threonine kinase 38 like	1
<a href="#">11022</a>	TDRKH	tudor and KH domain containing	1
<a href="#">4151</a>	MB	myoglobin	1
<a href="#">26090</a>	ABHD12	abhydrolase domain containing 13	1
<a href="#">89927</a>	C16orf45	chromosome 16 open reading frame 46	1
<a href="#">8600</a>	TNFSF11	tumor necrosis factor superfamily member 12	1
<a href="#">3394</a>	IRF8	interferon regulatory factor 9	1
<a href="#">5606</a>	MAP2K3	mitogen-activated protein kinase kinase 4	1
<a href="#">2539</a>	G6PD	glucose-6-phosphate dehydrogenase	1
<a href="#">7074</a>	TIAM1	T-cell lymphoma invasion and metastasis 2	1
<a href="#">518</a>	ATP5G3	ATP synthase, H+ transporting, mitochondrial Fo complex subunit C3 (subunit 9)	1
<a href="#">3732</a>	CD82	CD82 molecule	1
<a href="#">619279</a>	ZNF704	zinc finger protein 705	1

<a href="#">5683</a>	PSMA2	proteasome subunit alpha 2	1
<a href="#">5689</a>	PSMB1	proteasome subunit beta 1	1
<a href="#">10808</a>	HSPH1	heat shock protein family H (Hsp110) member 1	1
<a href="#">3274</a>	HRH2	histamine receptor H2	1
<a href="#">10128</a>	LRPPRC	leucine rich pentatricopeptide repeat containing	1
<a href="#">1718</a>	DHCR24	24-dehydrocholesterol reductase	1
<a href="#">84679</a>	SLC9A7	solute carrier family 9 member A7	1
<a href="#">80185</a>	TTI2	TELO2 interacting protein 2	1
<a href="#">84890</a>	ADO	2-aminoethanethiol dioxygenase	1
<a href="#">388753</a>	COA6	cytochrome c oxidase assembly factor 6	1
<a href="#">8140</a>	SLC7A5	solute carrier family 7 member 5	1
<a href="#">55486</a>	PARL	presenilin associated rhomboid like	1
<a href="#">7415</a>	VCP	valosin containing protein	1
<a href="#">2180</a>	ACSL1	acyl-CoA synthetase long-chain family member 1	1
<a href="#">7803</a>	PTP4A1	protein tyrosine phosphatase type IVA, member 1	1
<a href="#">29107</a>	NXT1	nuclear transport factor 2 like export factor 1	1
<a href="#">53615</a>	MBD3	methyl-CpG binding domain protein 3	1
<a href="#">84328</a>	LZIC	leucine zipper and CTNNBIP1 domain containing	1
<a href="#">51428</a>	DDX41	DEAD-box helicase 41	1
<a href="#">150678</a>	COPS9	COP9 signalosome subunit 9	1
<a href="#">54915</a>	YTHDF1	YTH N6-methyladenosine RNA binding protein 1	1
<a href="#">1368</a>	CPM	carboxypeptidase M	1
<a href="#">7128</a>	TNFAIP3	TNF alpha induced protein 3	1
<a href="#">81570</a>	CLPB	ClpB homolog, mitochondrial AAA ATPase chaperonin	1
<a href="#">7071</a>	KLF10	Kruppel like factor 10	1
<a href="#">3725</a>	JUN	Jun proto-oncogene, AP-1 transcription factor subunit	1
<a href="#">22827</a>	PUF60	poly(U) binding splicing factor 60	1
<a href="#">54733</a>	SLC35F2	solute carrier family 35 member F2	1
<a href="#">2153</a>	F5	coagulation factor V	1
<a href="#">3516</a>	RBPJ	recombination signal binding protein for immunoglobulin kappa J region	1
<a href="#">7203</a>	CCT3	chaperonin containing TCP1 subunit 3	1
<a href="#">4869</a>	NPM1	nucleophosmin	1
<a href="#">22948</a>	CCT5	chaperonin containing TCP1 subunit 5	1
<a href="#">54888</a>	NSUN2	NOP2/Sun RNA methyltransferase family member 2	1
<a href="#">11001</a>	SLC27A2	solute carrier family 27 member 2	1
<a href="#">11169</a>	WDHD1	WD repeat and HMG-box DNA binding protein 1	1
<a href="#">2107</a>	ETF1	eukaryotic translation termination factor 1	1
<a href="#">8568</a>	RRP1	ribosomal RNA processing 1	1
<a href="#">2023</a>	ENO1	enolase 1	1
<a href="#">50628</a>	GEMIN4	gem nuclear organelle associated protein 4	1
<a href="#">9322</a>	TRIP10	thyroid hormone receptor interactor 10	1
<a href="#">84295</a>	PHF6	PHD finger protein 6	1
<a href="#">9939</a>	RBM8A	RNA binding motif protein 8A	1
<a href="#">55605</a>	KIF21A	kinesin family member 21A	1
<a href="#">1173</a>	AP2M1	adaptor related protein complex 2 mu 1 subunit	1
<a href="#">9618</a>	TRAF4	TNF receptor associated factor 4	1
<a href="#">10098</a>	TSPAN5	tetraspanin 5	1
<a href="#">23246</a>	BOP1	block of proliferation 1	1
<a href="#">6385</a>	SDC4	syndecan 4	1
<a href="#">908</a>	CCT6A	chaperonin containing TCP1 subunit 6A	1
<a href="#">54206</a>	ERRFI1	ERBB receptor feedback inhibitor 1	1
<a href="#">28984</a>	RGCC	regulator of cell cycle	1
<a href="#">5315</a>	PKM	pyruvate kinase, muscle	1
<a href="#">402055</a>	SRRD	SRR1 domain containing	1
<a href="#">3028</a>	HSD17B10	hydroxysteroid 17-beta dehydrogenase 10	1
<a href="#">10783</a>	NEK6	NIMA related kinase 6	1
<a href="#">26521</a>	TIMM8B	translocase of inner mitochondrial membrane 8 homolog B	1
<a href="#">10067</a>	SCAMP3	secretory carrier membrane protein 3	1
<a href="#">4706</a>	NDUFAB1	NADH:ubiquinone oxidoreductase subunit AB1	1
<a href="#">10514</a>	MYBBP1A	MYB binding protein 1a	1
<a href="#">10541</a>	ANP32B	acidic nuclear phosphoprotein 32 family member B	1
<a href="#">27044</a>	SND1	staphylococcal nuclease and tudor domain containing 1	1
<a href="#">4121</a>	MAN1A1	mannosidase alpha class 1A member 1	1
<a href="#">3945</a>	LDHB	lactate dehydrogenase B	1
<a href="#">84946</a>	LTV1	LTV1 ribosome biogenesis factor	1

<a href="#">9456</a>	HOMER1	homer scaffolding protein 1	1
<a href="#">80896</a>	NPL	N-acetylneuraminatate pyruvate lyase	1
<a href="#">1026</a>	CDKN1A	cyclin dependent kinase inhibitor 1A	1
<a href="#">50615</a>	IL21R	interleukin 21 receptor	1
<a href="#">83858</a>	ATAD3B	ATPase family, AAA domain containing 3B	1
<a href="#">3326</a>	HSP90AB1	heat shock protein 90 alpha family class B member 1	1
<a href="#">1493</a>	CTLA4	cytotoxic T-lymphocyte associated protein 4	1
<a href="#">8444</a>	DYRK3	dual specificity tyrosine phosphorylation regulated kinase 3	1
<a href="#">23135</a>	KDM6B	lysine demethylase 6B	1
<a href="#">23223</a>	RRP12	ribosomal RNA processing 12 homolog	1
<a href="#">25902</a>	MTHFD1L	methylenetetrahydrofolate dehydrogenase (NADP+ dependent) 1-like	1
<a href="#">22856</a>	CHSY1	chondroitin sulfate synthase 1	1
<a href="#">85458</a>	DIXDC1	DIX domain containing 1	1
<a href="#">817</a>	CAMK2D	calcium/calmodulin dependent protein kinase II delta	1
<a href="#">10252</a>	SPRY1	sprouty RTK signaling antagonist 1	1
<a href="#">25911</a>	DPCD	deleted in primary ciliary dyskinesia homolog (mouse)	1
<a href="#">219</a>	ALDH1B1	aldehyde dehydrogenase 1 family member B1	1
<a href="#">57213</a>	SPRYD7	SPRY domain containing 7	1
<a href="#">10171</a>	RCL1	RNA terminal phosphate cyclase like 1	1
<a href="#">5516</a>	PPP2CB	protein phosphatase 2 catalytic subunit beta	1
<a href="#">25929</a>	GEMIN5	gem nuclear organelle associated protein 5	1
<a href="#">55161</a>	TMEM33	transmembrane protein 33	1
<a href="#">25778</a>	DSTYK	dual serine/threonine and tyrosine protein kinase	1
<a href="#">11338</a>	U2AF2	U2 small nuclear RNA auxiliary factor 2	1
<a href="#">283871</a>	PGP	phosphoglycolate phosphatase	1
<a href="#">8884</a>	SLC5A6	solute carrier family 5 member 6	1
<a href="#">79586</a>	CHPF	chondroitin polymerizing factor	1
<a href="#">283373</a>	ANKRD52	ankyrin repeat domain 52	1
<a href="#">55319</a>	TMA16	translation machinery associated 16 homolog	1
<a href="#">55269</a>	PSPC1	paraspeckle component 1	1
<a href="#">7511</a>	XPNPEP1	X-prolyl aminopeptidase 1	1
<a href="#">1836</a>	SLC26A2	solute carrier family 26 member 2	1
<a href="#">113251</a>	LARP4	La ribonucleoprotein domain family member 4	1
<a href="#">9656</a>	MDC1	mediator of DNA damage checkpoint 1	1
<a href="#">254428</a>	SLC41A1	solute carrier family 41 member 1	1
<a href="#">8161</a>	COIL	coilin	1
<a href="#">65059</a>	RAPH1	Ras association (RalGDS/AF-6) and pleckstrin homology domains 1	1
<a href="#">8807</a>	IL18RAP	interleukin 18 receptor accessory protein	1
<a href="#">10018</a>	BCL2L11	BCL2 like 11	1
<a href="#">2597</a>	GAPDH	glyceraldehyde-3-phosphate dehydrogenase	1
<a href="#">6907</a>	TBL1X	transducin beta like 1X-linked	1
<a href="#">9047</a>	SH2D2A	SH2 domain containing 2A	1
<a href="#">64759</a>	TNS3	tensin 3	1
<a href="#">200734</a>	SPRED2	sprouty related EVH1 domain containing 2	1
<a href="#">6050</a>	RNH1	ribonuclease/angiogenin inhibitor 1	1
<a href="#">1390</a>	CREM	cAMP responsive element modulator	1
<a href="#">4810</a>	NHS	NHS actin remodeling regulator	1
<a href="#">969</a>	CD69	CD69 molecule	1
<a href="#">597</a>	BCL2A1	BCL2 related protein A1	1
<a href="#">1293</a>	COL6A3	collagen type VI alpha 3 chain	1
<a href="#">64218</a>	SEMA4A	semaphorin 4A	1
<a href="#">8464</a>	SUPT3H	SPT3 homolog, SAGA and STAGA complex component	1
<a href="#">3557</a>	IL1RN	interleukin 1 receptor antagonist	1
<a href="#">6319</a>	SCD	stearoyl-CoA desaturase	1
<a href="#">10849</a>	CD3EAP	CD3e molecule associated protein	1
<a href="#">50</a>	ACO2	aconitase 2	1
<a href="#">160760</a>	PPTC7	PTC7 protein phosphatase homolog	1
<a href="#">51255</a>	RNF181	ring finger protein 181	1
<a href="#">90378</a>	SAMD1	sterile alpha motif domain containing 1	1
<a href="#">191</a>	AHCY	adenosylhomocysteinase	1
<a href="#">9446</a>	GSTO1	glutathione S-transferase omega 1	1
<a href="#">6780</a>	STAU1	staufen double-stranded RNA binding protein 1	1
<a href="#">9112</a>	MTA1	metastasis associated 1	1
<a href="#">2885</a>	GRB2	growth factor receptor bound protein 2	1
<a href="#">4642</a>	MYO1D	myosin ID	1

<a href="#">10273</a>	STUB1	STIP1 homology and U-box containing protein 1	1
<a href="#">64651</a>	CSRNP1	cysteine and serine rich nuclear protein 1	1
<a href="#">22822</a>	PHLDA1	pleckstrin homology like domain family A member 1	1
<a href="#">8566</a>	PDXK	pyridoxal (pyridoxine, vitamin B6) kinase	1
<a href="#">8482</a>	SEMA7A	semaphorin 7A (John Milton Hagen blood group)	1
<a href="#">7421</a>	VDR	vitamin D (1,25- dihydroxyvitamin D3) receptor	1
<a href="#">59269</a>	HIVEP3	human immunodeficiency virus type I enhancer binding protein 3	1
<a href="#">54602</a>	NDFIP2	Nedd4 family interacting protein 2	1
<a href="#">1958</a>	EGR1	early growth response 1	1
<a href="#">1846</a>	DUSP4	dual specificity phosphatase 4	1
<a href="#">1959</a>	EGR2	early growth response 2	1
<a href="#">135228</a>	CD109	CD109 molecule	1
<a href="#">8013</a>	NR4A3	nuclear receptor subfamily 4 group A member 3	1
<a href="#">4345</a>	CD200	CD200 molecule	1
<a href="#">3604</a>	TNFRSF9	TNF receptor superfamily member 9	1
<a href="#">51320</a>	MEX3C	mex-3 RNA binding family member C	1
<a href="#">9645</a>	MICAL2	microtubule associated monooxygenase, calponin and LIM domain containing 2	1
<a href="#">5738</a>	PTGFRN	prostaglandin F2 receptor inhibitor	1
<a href="#">6004</a>	RGS16	regulator of G-protein signaling 16	1
<a href="#">9669</a>	EIF5B	eukaryotic translation initiation factor 5B	1
<a href="#">3662</a>	IRF4	interferon regulatory factor 4	1
<a href="#">57109</a>	REXO4	REX4 homolog, 3'-5' exonuclease	1
<a href="#">79814</a>	AGMAT	agmatinase	1
<a href="#">55544</a>	RBM38	RNA binding motif protein 38	1
<a href="#">9904</a>	RBM19	RNA binding motif protein 19	1
<a href="#">10488</a>	CREB3	cAMP responsive element binding protein 3	1
<a href="#">4791</a>	NFKB2	nuclear factor kappa B subunit 2	1
<a href="#">54874</a>	FNBP1L	formin binding protein 1 like	1
<a href="#">55640</a>	FLVCR2	feline leukemia virus subgroup C cellular receptor family member 2	1
<a href="#">9513</a>	FXR2	FMR1 autosomal homolog 2	1
<a href="#">29979</a>	UBQLN1	ubiquilin 1	1
<a href="#">55341</a>	LSG1	large 60S subunit nuclear export GTPase 1	1
<a href="#">9987</a>	HNRNPDL	heterogeneous nuclear ribonucleoprotein D like	1
<a href="#">3783</a>	KCNN4	potassium calcium-activated channel subfamily N member 4	1
<a href="#">6520</a>	SLC3A2	solute carrier family 3 member 2	1
<a href="#">26574</a>	AATF	apoptosis antagonizing transcription factor	1
<a href="#">56957</a>	OTUD7B	OTU deubiquitinase 7B	1
<a href="#">65094</a>	JMJD4	jumonji domain containing 4	1
<a href="#">56270</a>	WDR45B	WD repeat domain 45B	1
<a href="#">5688</a>	PSMA7	proteasome subunit alpha 7	1
<a href="#">51042</a>	ZNF593	zinc finger protein 593	1
<a href="#">3727</a>	JUND	JunD proto-oncogene, AP-1 transcription factor subunit	1
<a href="#">85437</a>	ZCRB1	zinc finger CCHC-type and RNA binding motif containing 1	1
<a href="#">55813</a>	UTP6	UTP6, small subunit processome component	1
<a href="#">90480</a>	GADD45GIP1	GADD45G interacting protein 1	1
<a href="#">5831</a>	PYCR1	pyrroline-5-carboxylate reductase 1	1
<a href="#">4643</a>	MYO1E	myosin IE	1
<a href="#">1407</a>	CRY1	cryptochrome circadian clock 1	1
<a href="#">1329</a>	COX5B	cytochrome c oxidase subunit 5B	1
<a href="#">7915</a>	ALDH5A1	aldehyde dehydrogenase 5 family member A1	1
<a href="#">51529</a>	ANAPC11	anaphase promoting complex subunit 11	1
<a href="#">31</a>	ACACA	acetyl-CoA carboxylase alpha	1
<a href="#">57568</a>	SIPA1L2	signal induced proliferation associated 1 like 2	1
<a href="#">6599</a>	SMARCC1	SWI/SNF related, matrix associated, actin dependent regulator of chromatin subfamily c member 1	1
<a href="#">9486</a>	CHST10	carbohydrate sulfotransferase 10	1
<a href="#">56938</a>	ARNTL2	aryl hydrocarbon receptor nuclear translocator like 2	1
<a href="#">3192</a>	HNRNPU	heterogeneous nuclear ribonucleoprotein U	1
<a href="#">23507</a>	LRRC8B	leucine rich repeat containing 8 family member B	1
<a href="#">26031</a>	OSBPL3	oxysterol binding protein like 3	1
<a href="#">7528</a>	YY1	YY1 transcription factor	1
<a href="#">23429</a>	RYBP	RING1 and YY1 binding protein	1
<a href="#">5591</a>	PRKDC	protein kinase, DNA-activated, catalytic polypeptide	1
<a href="#">7525</a>	YES1	YES proto-oncogene 1, Src family tyrosine kinase	1
<a href="#">8932</a>	MBD2	methyl-CpG binding domain protein 2	1

<a href="#">4779</a>	NFE2L1	nuclear factor, erythroid 2 like 1	1
<a href="#">3054</a>	HCFC1	host cell factor C1	1
<a href="#">2194</a>	FASN	fatty acid synthase	1
<a href="#">28964</a>	GIT1	GIT ArfGAP 1	1
<a href="#">29886</a>	SNX8	sorting nexin 8	1
<a href="#">10153</a>	CEBPZ	CCAAT/enhancer binding protein zeta	1
<a href="#">79050</a>	NOC4L	nucleolar complex associated 4 homolog	1
<a href="#">10400</a>	PEMT	phosphatidylethanolamine N-methyltransferase	1
<a href="#">115353</a>	LRRC42	leucine rich repeat containing 42	1
<a href="#">57478</a>	USP31	ubiquitin specific peptidase 31	1
<a href="#">1459</a>	CSNK2A2	casein kinase 2 alpha 2	1
<a href="#">282969</a>	FUOM	fucose mutarotase	1
<a href="#">84320</a>	ACBD6	acyl-CoA binding domain containing 6	1
<a href="#">56259</a>	CTNBL1	catenin beta like 1	1
<a href="#">254394</a>	MCM9	minichromosome maintenance 9 homologous recombination repair factor	1
<a href="#">4884</a>	NPTX1	neuronal pentraxin 1	1
<a href="#">10804</a>	GJB6	gap junction protein beta 6	1
<a href="#">6617</a>	SNAPC1	small nuclear RNA activating complex polypeptide 1	1
<a href="#">57584</a>	ARHGAP21	Rho GTPase activating protein 21	1
<a href="#">4763</a>	NF1	neurofibromin 1	1
<a href="#">7486</a>	WRN	Werner syndrome RecQ like helicase	1
<a href="#">11325</a>	DDX42	DEAD-box helicase 42	1
<a href="#">10975</a>	UQCRC1	ubiquinol-cytochrome c reductase, complex III subunit XI	1
<a href="#">5424</a>	POLD1	DNA polymerase delta 1, catalytic subunit	1
<a href="#">9986</a>	RCE1	Ras converting CAAX endopeptidase 1	1
<a href="#">90525</a>	SHF	Src homology 2 domain containing F	1
<a href="#">55760</a>	DHX32	DEAH-box helicase 32 (putative)	1
<a href="#">1263</a>	PLK3	polo like kinase 3	1
<a href="#">8651</a>	SOCS1	suppressor of cytokine signaling 1	1
<a href="#">54936</a>	ADPRHL2	ADP-ribosylhydrolase like 2	1
<a href="#">5531</a>	PPP4C	protein phosphatase 4 catalytic subunit	1
<a href="#">23640</a>	HSPBP1	HSPA (Hsp70) binding protein 1	1
<a href="#">113000</a>	RPUSD1	RNA pseudouridylylase domain containing 1	1
<a href="#">55527</a>	FEM1A	fem-1 homolog A	1
<a href="#">1175</a>	AP2S1	adaptor related protein complex 2 sigma 1 subunit	1
<a href="#">148022</a>	TICAM1	toll like receptor adaptor molecule 1	1
<a href="#">55684</a>	RABL6	RAB, member RAS oncogene family-like 6	1
<a href="#">8175</a>	SF3A2	splicing factor 3a subunit 2	1
<a href="#">284106</a>	CISD3	CDGSH iron sulfur domain 3	1
<a href="#">125988</a>	C19orf70	chromosome 19 open reading frame 70	1
<a href="#">84134</a>	TOMM40L	translocase of outer mitochondrial membrane 40 like	1
<a href="#">5094</a>	PCBP2	poly(rC) binding protein 2	1
<a href="#">11140</a>	CDC37	cell division cycle 37	1
<a href="#">2354</a>	FOSB	FosB proto-oncogene, AP-1 transcription factor subunit	1
<a href="#">84216</a>	TMEM117	transmembrane protein 117	1
<a href="#">677</a>	ZFP36L1	ZFP36 ring finger protein like 1	1
<a href="#">7040</a>	TGFB1	transforming growth factor beta 1	1
<a href="#">9265</a>	CYTH3	cytohesin 3	1
<a href="#">80700</a>	UBXN6	UBX domain protein 6	1
<a href="#">10048</a>	RANBP9	RAN binding protein 9	1
<a href="#">3560</a>	IL2RB	interleukin 2 receptor subunit beta	1
<a href="#">7763</a>	ZFAND5	zinc finger AN1-type containing 5	1
<a href="#">9249</a>	DHRS3	dehydrogenase/reductase 3	1
<a href="#">51564</a>	HDAC7	histone deacetylase 7	1
<a href="#">92558</a>	BICDL1	BICD family like cargo adaptor 1	1
<a href="#">26262</a>	TSPAN17	tetraspanin 17	1
<a href="#">54985</a>	HCFC1R1	host cell factor C1 regulator 1	1
<a href="#">923</a>	CD6	CD6 molecule	1
<a href="#">10625</a>	IVNS1ABP	influenza virus NS1A binding protein	1
<a href="#">57062</a>	DDX24	DEAD-box helicase 24	1
<a href="#">22859</a>	ADGRL1	adhesion G protein-coupled receptor L1	1
<a href="#">79169</a>	C1orf35	chromosome 1 open reading frame 35	1
<a href="#">7057</a>	THBS1	thrombospondin 1	1
<a href="#">1105</a>	CHD1	chromodomain helicase DNA binding protein 1	1
<a href="#">113246</a>	C12orf57	chromosome 12 open reading frame 57	1
<a href="#">6193</a>	RPS5	ribosomal protein S5	1

<a href="#">353322</a>	ANKRD37	ankyrin repeat domain 37	1
<a href="#">140823</a>	ROMO1	reactive oxygen species modulator 1	1
<a href="#">401052</a>	LOC401052	uncharacterized LOC401052	1
<a href="#">10948</a>	STAR3	StAR related lipid transfer domain containing 3	1
<a href="#">80198</a>	MUS81	MUS81 structure-specific endonuclease subunit	1
<a href="#">1855</a>	DVL1	dishevelled segment polarity protein 1	1
<a href="#">3556</a>	IL1RAP	interleukin 1 receptor accessory protein	1
<a href="#">4602</a>	MYB	MYB proto-oncogene, transcription factor	1
<a href="#">8496</a>	PPFIBP1	PPFIA binding protein 1	1
<a href="#">1960</a>	EGR3	early growth response 3	1
<a href="#">3164</a>	NR4A1	nuclear receptor subfamily 4 group A member 1	1
<a href="#">4862</a>	NPAS2	neuronal PAS domain protein 2	1
<a href="#">2672</a>	GFI1	growth factor independent 1 transcriptional repressor	1
<a href="#">5270</a>	SERPINE2	serpin family E member 2	1
<a href="#">57190</a>	SELENON	selenoprotein N	1
<a href="#">54815</a>	GATAD2A	GATA zinc finger domain containing 2A	1
<a href="#">8270</a>	LAGE3	L antigen family member 3	1
<a href="#">5524</a>	PTPA	protein phosphatase 2 phosphatase activator	1
<a href="#">57688</a>	ZSWIM6	zinc finger SWIM-type containing 6	1
<a href="#">51079</a>	NDUFA13	NADH:ubiquinone oxidoreductase subunit A13	1
<a href="#">3720</a>	JARID2	jumonji and AT-rich interaction domain containing 2	1
<a href="#">4851</a>	NOTCH1	notch 1	1
<a href="#">23326</a>	USP22	ubiquitin specific peptidase 22	1
<a href="#">6938</a>	TCF12	transcription factor 12	1
<a href="#">9704</a>	DHX34	DEAH-box helicase 34	1
<a href="#">26155</a>	NOC2L	NOC2 like nucleolar associated transcriptional repressor	1
<a href="#">165</a>	AEBP1	AE binding protein 1	1
<a href="#">115024</a>	NT5C3B	5'-nucleotidase, cytosolic IIIB	1
<a href="#">10865</a>	ARID5A	AT-rich interaction domain 5A	1
<a href="#">26051</a>	PPP1R16B	protein phosphatase 1 regulatory subunit 16B	1
<a href="#">728489</a>	DNLZ	DNL-type zinc finger	1
<a href="#">8761</a>	PABPC4	poly(A) binding protein cytoplasmic 4	1
<a href="#">2768</a>	GNA12	G protein subunit alpha 12	1
<a href="#">6633</a>	SNRPD2	small nuclear ribonucleoprotein D2 polypeptide	1
<a href="#">7265</a>	TTC1	tetratricopeptide repeat domain 1	1
<a href="#">2879</a>	GPX4	glutathione peroxidase 4	1
<a href="#">59286</a>	UBL5	ubiquitin like 5	1
<a href="#">5971</a>	RELB	RELB proto-oncogene, NF-kB subunit	1
<a href="#">9092</a>	SART1	squamous cell carcinoma antigen recognized by T-cells 1	1
<a href="#">23020</a>	SNRNP200	small nuclear ribonucleoprotein U5 subunit 200	1
<a href="#">123169</a>	LEO1	LEO1 homolog, Paf1/RNA polymerase II complex component	1
<a href="#">3995</a>	FADS3	fatty acid desaturase 3	1
<a href="#">4298</a>	MLLT1	MLLT1, super elongation complex subunit	1
<a href="#">54926</a>	UBE2R2	ubiquitin conjugating enzyme E2 R2	1
<a href="#">3984</a>	LIMK1	LIM domain kinase 1	1
<a href="#">5966</a>	REL	REL proto-oncogene, NF-kB subunit	1
<a href="#">10451</a>	VAV3	vav guanine nucleotide exchange factor 3	1
<a href="#">6713</a>	SQLE	squalene epoxidase	1
<a href="#">3309</a>	HSPA5	heat shock protein family A (Hsp70) member 5	1
<a href="#">79876</a>	UBA5	ubiquitin like modifier activating enzyme 5	1
<a href="#">2534</a>	FYN	FYN proto-oncogene, Src family tyrosine kinase	1
<a href="#">84524</a>	ZC3H8	zinc finger CCCH-type containing 8	1
<a href="#">56937</a>	PMEPA1	prostate transmembrane protein, androgen induced 1	1
<a href="#">7016</a>	TESK1	testis-specific kinase 1	1
<a href="#">7185</a>	TRAF1	TNF receptor associated factor 1	1
<a href="#">10746</a>	MAP3K2	mitogen-activated protein kinase kinase kinase 2	1
<a href="#">51429</a>	SNX9	sorting nexin 9	1
<a href="#">55342</a>	STRBP	spermatid perinuclear RNA binding protein	1
<a href="#">56172</a>	ANKH	ANKH inorganic pyrophosphate transport regulator	1
<a href="#">54880</a>	BCOR	BCL6 corepressor	1
<a href="#">9766</a>	SUSD6	sushi domain containing 6	1
<a href="#">6722</a>	SRF	serum response factor	1
<a href="#">9603</a>	NFE2L3	nuclear factor, erythroid 2 like 3	1
<a href="#">27161</a>	AGO2	argonaute 2, RISC catalytic component	1
<a href="#">29954</a>	POMT2	protein O-mannosyltransferase 2	1

<a href="#">8428</a>	STK24	serine/threonine kinase 24	1
<a href="#">10072</a>	DPP3	dipeptidyl peptidase 3	1
<a href="#">4282</a>	MIF	macrophage migration inhibitory factor (glycosylation-inhibiting factor)	1
<a href="#">22876</a>	INPP5F	inositol polyphosphate-5-phosphatase F	1
<a href="#">3399</a>	ID3	inhibitor of DNA binding 3, HLH protein	1
<a href="#">26018</a>	LRIG1	leucine rich repeats and immunoglobulin like domains 1	1
<a href="#">2275</a>	FHL3	four and a half LIM domains 3	1
<a href="#">153020</a>	RASGEF1B	RasGEF domain family member 1B	1
<a href="#">55589</a>	BMP2K	BMP2 inducible kinase	1
<a href="#">23683</a>	PRKD3	protein kinase D3	1
<a href="#">25797</a>	QPCT	glutaminyl-peptide cyclotransferase	1
<a href="#">23541</a>	SEC14L2	SEC14 like lipid binding 2	1
<a href="#">4929</a>	NR4A2	nuclear receptor subfamily 4 group A member 2	1
<a href="#">55573</a>	CDV3	CDV3 homolog	1
<a href="#">55353</a>	LAPTM4B	lysosomal protein transmembrane 4 beta	1
<a href="#">5367</a>	PMCH	pro-melanin concentrating hormone	1
<a href="#">9076</a>	CLDN1	claudin 1	1
<a href="#">3267</a>	AGFG1	ArfGAP with FG repeats 1	1
<a href="#">27076</a>	LYPD3	LY6/PLAUR domain containing 3	1
<a href="#">521</a>	ATP5I	ATP synthase, H <sup>+</sup> transporting, mitochondrial Fo complex subunit E	1
<a href="#">1340</a>	COX6B1	cytochrome c oxidase subunit 6B1	1
<a href="#">51700</a>	CYB5R2	cytochrome b5 reductase 2	1
<a href="#">2118</a>	ETV4	ETS variant 4	1
<a href="#">54935</a>	DUSP23	dual specificity phosphatase 23	1
<a href="#">6168</a>	RPL37A	ribosomal protein L37a	1
<a href="#">79763</a>	ISOC2	isochorismatase domain containing 2	1
<a href="#">55621</a>	TRMT1	tRNA methyltransferase 1	1
<a href="#">11267</a>	SNF8	SNF8, ESCRT-II complex subunit	1
<a href="#">1347</a>	COX7A2	cytochrome c oxidase subunit 7A2	1
<a href="#">79724</a>	ZNF768	zinc finger protein 768	1
<a href="#">28955</a>	DEXI	Dexi homolog	1
<a href="#">10555</a>	AGPAT2	1-acylglycerol-3-phosphate O-acyltransferase 2	1
<a href="#">143903</a>	LAYN	layilin	1
<a href="#">283209</a>	PGM2L1	phosphoglucomutase 2 like 1	1
<a href="#">8507</a>	ENC1	ectodermal-neural cortex 1	1
<a href="#">9749</a>	PHACTR2	phosphatase and actin regulator 2	1
<a href="#">7390</a>	UROS	uroporphyrinogen III synthase	1
<a href="#">84293</a>	FAM213A	family with sequence similarity 213 member A	1
<a href="#">169792</a>	GLIS3	GLIS family zinc finger 3	1
<a href="#">11019</a>	LIAS	lipoic acid synthetase	1
<a href="#">9537</a>	TP53I11	tumor protein p53 inducible protein 11	1
<a href="#">64092</a>	SAMSN1	SAM domain, SH3 domain and nuclear localization signals 1	1
<a href="#">9398</a>	CD101	CD101 molecule	1
<a href="#">128866</a>	CHMP4B	charged multivesicular body protein 4B	1
<a href="#">914</a>	CD2	CD2 molecule	1
<a href="#">56941</a>	HMCES	5-hydroxymethylcytosine (hmC) binding, ES cell-specific	1
<a href="#">2744</a>	GLS	glutaminase	1
<a href="#">481</a>	ATP1B1	ATPase Na <sup>+</sup> /K <sup>+</sup> transporting subunit beta 1	1
<a href="#">7832</a>	BTG2	BTG anti-proliferation factor 2	1
<a href="#">121260</a>	SLC15A4	solute carrier family 15 member 4	1
<a href="#">91647</a>	ATPAF2	ATP synthase mitochondrial F1 complex assembly factor 2	1
<a href="#">11319</a>	ECD	ecdysoneless cell cycle regulator	1
<a href="#">473</a>	RERE	arginine-glutamic acid dipeptide repeats	1
<a href="#">6830</a>	SUPT6H	SPT6 homolog, histone chaperone	1
<a href="#">10428</a>	CFDP1	craniofacial development protein 1	1
<a href="#">2969</a>	GTF2I	general transcription factor Iii	1
<a href="#">23396</a>	PIPSK1C	phosphatidylinositol-4-phosphate 5-kinase type 1 gamma	1
<a href="#">220213</a>	OTUD1	OTU deubiquitinase 1	1
<a href="#">5937</a>	RBMS1	RNA binding motif single stranded interacting protein 1	1
<a href="#">60436</a>	TGIF2	TGFB induced factor homeobox 2	1
<a href="#">4772</a>	NFATC1	nuclear factor of activated T-cells 1	1
<a href="#">2026</a>	ENO2	enolase 2	1
<a href="#">6774</a>	STAT3	signal transducer and activator of transcription 3	1
<a href="#">80233</a>	FAAP100	Fanconi anemia core complex associated protein 100	1
<a href="#">9859</a>	CEP170	centrosomal protein 170	1

<a href="#">3091</a>	HIF1A	hypoxia inducible factor 1 alpha subunit	1
<a href="#">26278</a>	SACS	sacsin molecular chaperone	1
<a href="#">8202</a>	NCOA3	nuclear receptor coactivator 3	1
<a href="#">4928</a>	NUP98	nucleoporin 98	1
<a href="#">3446</a>	IFNA10	interferon alpha 10	1
<a href="#">4637</a>	MYL6	myosin light chain 6	1
<a href="#">51192</a>	CKLF	chemokine like factor	1
<a href="#">11006</a>	LILRB4	leukocyte immunoglobulin like receptor B4	1
<a href="#">29085</a>	PHPT1	phosphohistidine phosphatase 1	1
<a href="#">10591</a>	DNPH1	2'-deoxynucleoside 5'-phosphate N-hydrolase 1	1
<a href="#">8871</a>	SYNJ2	synaptojanin 2	1
<a href="#">27151</a>	CPAMD8	C3 and PZP like, alpha-2-macroglobulin domain containing 8	1
<a href="#">4122</a>	MAN2A2	mannosidase alpha class 2A member 2	1
<a href="#">85450</a>	ITPRIP	inositol 1,4,5-trisphosphate receptor interacting protein	1
<a href="#">115708</a>	TRMT61A	tRNA methyltransferase 61A	1
<a href="#">119</a>	ADD2	adducin 2	1
<a href="#">100506581</a>	C16orf95	chromosome 16 open reading frame 95	1
<a href="#">25814</a>	ATXN10	ataxin 10	1
<a href="#">2004</a>	ELK3	ELK3, ETS transcription factor	1
<a href="#">23670</a>	TMEM2	transmembrane protein 2	1
<a href="#">1119</a>	CHKA	choline kinase alpha	1
<a href="#">51530</a>	ZC3HC1	zinc finger C3HC-type containing 1	1
<a href="#">84865</a>	CCDC142	coiled-coil domain containing 142	1
<a href="#">94104</a>	PAXBP1	PAX3 and PAX7 binding protein 1	1
<a href="#">23138</a>	N4BP3	NEDD4 binding protein 3	1
<a href="#">55128</a>	TRIM68	tripartite motif containing 68	1
<a href="#">8505</a>	PARG	poly(ADP-ribose) glycohydrolase	1
<a href="#">7343</a>	UBTF	upstream binding transcription factor, RNA polymerase I	1
<a href="#">56970</a>	ATXN7L3	ataxin 7 like 3	1
<a href="#">2314</a>	FLII	FLII, actin remodeling protein	1
<a href="#">2622</a>	GAS8	growth arrest specific 8	1
<a href="#">7090</a>	TLE3	transducin like enhancer of split 3	1
<a href="#">64718</a>	UNKL	unkempt family like zinc finger	1
<a href="#">284654</a>	RSPO1	R-spondin 1	1
<a href="#">79171</a>	RBM42	RNA binding motif protein 42	1
<a href="#">7874</a>	USP7	ubiquitin specific peptidase 7	1
<a href="#">9757</a>	KMT2B	lysine methyltransferase 2B	1
<a href="#">37</a>	ACADVL	acyl-CoA dehydrogenase, very long chain	1
<a href="#">26279</a>	PLA2G2D	phospholipase A2 group IID	1
<a href="#">4296</a>	MAP3K11	mitogen-activated protein kinase kinase 11	1
<a href="#">5739</a>	PTGIR	prostaglandin I2 (prostacyclin) receptor (IP)	1
<a href="#">9058</a>	SLC13A2	solute carrier family 13 member 2	1
<a href="#">79064</a>	TMEM223	transmembrane protein 223	1
<a href="#">55206</a>	SBNO1	strawberry notch homolog 1	1
<a href="#">24148</a>	PRPF6	pre-mRNA processing factor 6	1
<a href="#">2535</a>	FZD2	frizzled class receptor 2	1
<a href="#">7259</a>	TSPYL1	TSPY like 1	1
<a href="#">8439</a>	NSMAF	neutral sphingomyelinase activation associated factor	1
<a href="#">150946</a>	GAREM2	GRB2 associated regulator of MAPK1 subtype 2	1
<a href="#">5213</a>	PFKM	phosphofructokinase, muscle	2
<a href="#">6429</a>	SRSF4	serine and arginine rich splicing factor 4	2
<a href="#">60481</a>	ELOVL5	ELOVL fatty acid elongase 5	2
<a href="#">966</a>	CD59	CD59 molecule	2
<a href="#">9276</a>	COPB2	coatamer protein complex subunit beta 2	2
<a href="#">51386</a>	EIF3L	eukaryotic translation initiation factor 3 subunit L	2
<a href="#">2072</a>	ERCC4	ERCC excision repair 4, endonuclease catalytic subunit	2
<a href="#">4358</a>	MPV17	MPV17, mitochondrial inner membrane protein	2
<a href="#">8655</a>	DYNLL1	dynein light chain LC8-type 1	2
<a href="#">80219</a>	COQ10B	coenzyme Q10B	2
<a href="#">8992</a>	ATP6V0E1	ATPase H+ transporting V0 subunit e1	2
<a href="#">148203</a>	ZNF738	zinc finger protein 738	2
<a href="#">93380</a>	MMGT1	membrane magnesium transporter 1	2
<a href="#">51060</a>	TXNDC12	thioredoxin domain containing 12	2
<a href="#">6539</a>	SLC6A12	solute carrier family 6 member 12	2
<a href="#">388591</a>	RNF207	ring finger protein 207	2

<a href="#">6727</a>	SRP14	signal recognition particle 14	2
<a href="#">729852</a>	UMAD1	UBAP1-MVB12-associated (UMA) domain containing 1	2
<a href="#">80381</a>	CD276	CD276 molecule	2
<a href="#">84258</a>	SYT3	synaptotagmin 3	2
<a href="#">23251</a>	KIAA1024	KIAA1024	2
<a href="#">114836</a>	SLAMF6	SLAM family member 6	2
<a href="#">6207</a>	RPS13	ribosomal protein S13	2
<a href="#">728798</a>	FRMPD2B	FERM and PDZ domain containing 2B, pseudogene	2
<a href="#">51759</a>	C9orf78	chromosome 9 open reading frame 78	2
<a href="#">8837</a>	CFLAR	CASP8 and FADD like apoptosis regulator	2
<a href="#">55012</a>	PPP2R3C	protein phosphatase 2 regulatory subunit B"gamma	2
<a href="#">118426</a>	BORCS5	BLOC-1 related complex subunit 5	2
<a href="#">8804</a>	CREG1	cellular repressor of E1A stimulated genes 1	2
<a href="#">51008</a>	ASCC1	activating signal cointegrator 1 complex subunit 1	2
<a href="#">142</a>	PARP1	poly(ADP-ribose) polymerase 1	2
<a href="#">90355</a>	C5orf30	chromosome 5 open reading frame 30	2
<a href="#">4802</a>	NFYC	nuclear transcription factor Y subunit gamma	2
<a href="#">51188</a>	SS18L2	SS18 like 2	2
<a href="#">84318</a>	CCDC77	coiled-coil domain containing 77	2
<a href="#">133015</a>	PACRGL	PARK2 coregulated like	2
<a href="#">79691</a>	QTRT2	queuine tRNA-ribosyltransferase accessory subunit 2	2
<a href="#">10055</a>	SAE1	SUMO1 activating enzyme subunit 1	2
<a href="#">8030</a>	CCDC6	coiled-coil domain containing 6	2
<a href="#">3383</a>	ICAM1	intercellular adhesion molecule 1	2
<a href="#">81691</a>	LOC81691	exonuclease NEF-sp	2
<a href="#">90417</a>	KNSTRN	kinetochore localized astrin/SPAG5 binding protein	2
<a href="#">7453</a>	WARS	tryptophanyl-tRNA synthetase	2
<a href="#">9232</a>	PTTG1	pituitary tumor-transforming 1	2
<a href="#">51155</a>	HN1	hematological and neurological expressed 1	2
<a href="#">11244</a>	ZHX1	zinc fingers and homeoboxes 1	2
<a href="#">6790</a>	AURKA	aurora kinase A	2
<a href="#">7049</a>	TGFBR3	transforming growth factor beta receptor 3	2
<a href="#">55165</a>	CEP55	centrosomal protein 55	2
<a href="#">57405</a>	SPC25	SPC25, NDC80 kinetochore complex component	2
<a href="#">221150</a>	SKA3	spindle and kinetochore associated complex subunit 3	2
<a href="#">157570</a>	ESCO2	establishment of sister chromatid cohesion N-acetyltransferase 2	2
<a href="#">9055</a>	PRC1	protein regulator of cytokinesis 1	2
<a href="#">157313</a>	CDCA2	cell division cycle associated 2	2
<a href="#">51433</a>	ANAPC5	anaphase promoting complex subunit 5	2
<a href="#">83540</a>	NUF2	NUF2, NDC80 kinetochore complex component	2
<a href="#">9738</a>	CCP110	centriolar coiled-coil protein 110	2
<a href="#">11183</a>	MAP4K5	mitogen-activated protein kinase kinase kinase 5	2
<a href="#">22974</a>	TPX2	TPX2, microtubule nucleation factor	2
<a href="#">10112</a>	KIF20A	kinesin family member 20A	2
<a href="#">3161</a>	HMMR	hyaluronan mediated motility receptor	2
<a href="#">79840</a>	NHEJ1	non-homologous end joining factor 1	2
<a href="#">3148</a>	HMGB2	high mobility group box 2	2
<a href="#">9787</a>	DLGAP5	DLG associated protein 5	2
<a href="#">9212</a>	AURKB	aurora kinase B	2
<a href="#">699</a>	BUB1	BUB1 mitotic checkpoint serine/threonine kinase	2
<a href="#">11113</a>	CIT	citron rho-interacting serine/threonine kinase	2
<a href="#">51203</a>	NUSAP1	nucleolar and spindle associated protein 1	2
<a href="#">644</a>	BLVRA	biliverdin reductase A	2
<a href="#">9928</a>	KIF14	kinesin family member 14	2
<a href="#">7153</a>	TOP2A	topoisomerase (DNA) II alpha	2
<a href="#">84548</a>	TMEM185A	transmembrane protein 185A	2
<a href="#">54842</a>	MFSD6	major facilitator superfamily domain containing 6	2
<a href="#">860</a>	RUNX2	runt related transcription factor 2	2
<a href="#">8501</a>	SLC43A1	solute carrier family 43 member 1	2
<a href="#">255231</a>	MCOLN2	mucopolip 2	2
<a href="#">1326</a>	MAP3K8	mitogen-activated protein kinase kinase kinase 8	2
<a href="#">4818</a>	NKG7	natural killer cell granule protein 7	2
<a href="#">347734</a>	SLC35B2	solute carrier family 35 member B2	2
<a href="#">2786</a>	GNG4	G protein subunit gamma 4	2
<a href="#">6574</a>	SLC20A1	solute carrier family 20 member 1	2

<a href="#">1889</a>	ECE1	endothelin converting enzyme 1	2
<a href="#">54977</a>	SLC25A38	solute carrier family 25 member 38	2
<a href="#">55362</a>	TMEM63B	transmembrane protein 63B	2
<a href="#">81562</a>	LMAN2L	lectin, mannose binding 2 like	2
<a href="#">55974</a>	SLC50A1	solute carrier family 50 member 1	2
<a href="#">55432</a>	YOD1	YOD1 deubiquitinase	2
<a href="#">64776</a>	C11orf1	chromosome 11 open reading frame 1	2
<a href="#">92335</a>	STRADA	STE20-related kinase adaptor alpha	2
<a href="#">5603</a>	MAPK13	mitogen-activated protein kinase 13	2
<a href="#">85235</a>	HIST1H2AH	histone cluster 1 H2A family member h	2
<a href="#">8360</a>	HIST1H4D	histone cluster 1 H4 family member d	2
<a href="#">3017</a>	HIST1H2BD	histone cluster 1 H2B family member d	2
<a href="#">8334</a>	HIST1H2AC	histone cluster 1 H2A family member c	2
<a href="#">3007</a>	HIST1H1D	histone cluster 1 H1 family member d	2
<a href="#">9447</a>	AIM2	absent in melanoma 2	2
<a href="#">51510</a>	CHMP5	charged multivesicular body protein 5	2
<a href="#">8969</a>	HIST1H2AG	histone cluster 1 H2A family member g	2
<a href="#">8336</a>	HIST1H2AM	histone cluster 1 H2A family member m	2
<a href="#">8339</a>	HIST1H2BG	histone cluster 1 H2B family member g	2
<a href="#">8329</a>	HIST1H2AI	histone cluster 1 H2A family member i	2
<a href="#">3012</a>	HIST1H2AE	histone cluster 1 H2A family member e	2
<a href="#">55145</a>	THAP1	THAP domain containing 1	2
<a href="#">55143</a>	CDCA8	cell division cycle associated 8	2
<a href="#">1870</a>	E2F2	E2F transcription factor 2	2
<a href="#">8365</a>	HIST1H4H	histone cluster 1 H4 family member h	2
<a href="#">10682</a>	EBP	emopamil binding protein (sterol isomerase)	2
<a href="#">51512</a>	GTSE1	G2 and S-phase expressed 1	2
<a href="#">8331</a>	HIST1H2AJ	histone cluster 1 H2A family member j	2
<a href="#">64792</a>	IFT22	intraflagellar transport 22	2
<a href="#">8342</a>	HIST1H2BM	histone cluster 1 H2B family member m	2
<a href="#">94120</a>	SYTL3	synaptotagmin like 3	2
<a href="#">64782</a>	AEN	apoptosis enhancing nuclease	2
<a href="#">64793</a>	CEP85	centrosomal protein 85	2
<a href="#">4717</a>	NDUFC1	NADH:ubiquinone oxidoreductase subunit C1	2
<a href="#">92815</a>	HIST3H2A	histone cluster 3 H2A	2
<a href="#">291</a>	SLC25A4	solute carrier family 25 member 4	2
<a href="#">10459</a>	MAD2L2	MAD2 mitotic arrest deficient-like 2 (yeast)	2
<a href="#">9242</a>	MSC	musculin	2
<a href="#">332</a>	BIRC5	baculoviral IAP repeat containing 5	2
<a href="#">3835</a>	KIF22	kinesin family member 22	2
<a href="#">1398</a>	CRK	CRK proto-oncogene, adaptor protein	2
<a href="#">8367</a>	HIST1H4E	histone cluster 1 H4 family member e	2
<a href="#">10945</a>	KDELRL1	KDEL endoplasmic reticulum protein retention receptor 1	2
<a href="#">79738</a>	BBS10	Bardet-Biedl syndrome 10	2
<a href="#">63931</a>	MRPS14	mitochondrial ribosomal protein S14	2
<a href="#">54987</a>	C1orf123	chromosome 1 open reading frame 123	2
<a href="#">4090</a>	SMAD5	SMAD family member 5	2
<a href="#">55831</a>	EMC3	ER membrane protein complex subunit 3	2
<a href="#">255520</a>	ELMOD2	ELMO domain containing 2	2
<a href="#">51128</a>	SAR1B	secretion associated Ras related GTPase 1B	2
<a href="#">55140</a>	ELP3	elongator acetyltransferase complex subunit 3	2
<a href="#">302</a>	ANXA2	annexin A2	2
<a href="#">149420</a>	PDIK1L	PDLIM1 interacting kinase 1 like	2
<a href="#">26586</a>	CKAP2	cytoskeleton associated protein 2	2
<a href="#">135114</a>	HINT3	histidine triad nucleotide binding protein 3	2
<a href="#">57102</a>	C12orf4	chromosome 12 open reading frame 4	2
<a href="#">219790</a>	RTKN2	rhotekin 2	2
<a href="#">80067</a>	DCAF17	DDB1 and CUL4 associated factor 17	2
<a href="#">1654</a>	DDX3X	DEAD-box helicase 3, X-linked	2
<a href="#">151188</a>	ARL6IP6	ADP ribosylation factor like GTPase 6 interacting protein 6	2
<a href="#">10313</a>	RTN3	reticulon 3	2
<a href="#">150468</a>	CKAP2L	cytoskeleton associated protein 2 like	2
<a href="#">55182</a>	RNF220	ring finger protein 220	2
<a href="#">9887</a>	SMG7	SMG7, nonsense mediated mRNA decay factor	2
<a href="#">5579</a>	PRKCB	protein kinase C beta	2

<a href="#">55435</a>	AP1AR	adaptor related protein complex 1 associated regulatory protein	2
<a href="#">253635</a>	GPATCH11	G-patch domain containing 11	2
<a href="#">55033</a>	FKBP14	FK506 binding protein 14	2
<a href="#">5355</a>	PLP2	proteolipid protein 2	2
<a href="#">51227</a>	PIGP	phosphatidylinositol glycan anchor biosynthesis class P	2
<a href="#">11321</a>	GPN1	GPN-loop GTPase 1	2
<a href="#">51573</a>	GDE1	glycerophosphodiester phosphodiesterase 1	2
<a href="#">23786</a>	BCL2L13	BCL2 like 13	2
<a href="#">6103</a>	RPGR	retinitis pigmentosa GTPase regulator	2
<a href="#">26263</a>	FBXO22	F-box protein 22	2
<a href="#">7163</a>	TPD52	tumor protein D52	2
<a href="#">51068</a>	NMD3	NMD3 ribosome export adaptor	2
<a href="#">51026</a>	GOLT1B	golgi transport 1B	2
<a href="#">122809</a>	SOCS4	suppressor of cytokine signaling 4	2
<a href="#">83695</a>	RHNO1	RAD9-HUS1-RAD1 interacting nuclear orphan 1	2
<a href="#">26040</a>	SETBP1	SET binding protein 1	2
<a href="#">5378</a>	PMS1	PMS1 homolog 1, mismatch repair system component	2
<a href="#">10641</a>	NPRL2	NPRL2-like, GATOR1 complex subunit	2
<a href="#">84967</a>	LSM10	LSM10, U7 small nuclear RNA associated	2
<a href="#">9702</a>	CEP57	centrosomal protein 57	2
<a href="#">23062</a>	GGA2	golgi associated, gamma adaptin ear containing, ARF binding protein 2	2
<a href="#">54780</a>	NMCE4A	NSE4 homolog A, SMC5-SMC6 complex component	2
<a href="#">199857</a>	ALG14	ALG14, UDP-N-acetylglucosaminyltransferase subunit	2
<a href="#">28977</a>	MRPL42	mitochondrial ribosomal protein L42	2
<a href="#">25996</a>	REXO2	RNA exonuclease 2	2
<a href="#">3364</a>	HUS1	HUS1 checkpoint clamp component	2
<a href="#">134359</a>	POC5	POC5 centriolar protein	2
<a href="#">64778</a>	FNDC3B	fibronectin type III domain containing 3B	2
<a href="#">256356</a>	GK5	glycerol kinase 5 (putative)	2
<a href="#">9194</a>	SLC16A7	solute carrier family 16 member 7	2
<a href="#">55037</a>	PTCD3	pentatricopeptide repeat domain 3	2
<a href="#">8148</a>	TAF15	TATA-box binding protein associated factor 15	2
<a href="#">285282</a>	RABL3	RAB, member of RAS oncogene family like 3	2
<a href="#">51095</a>	TRNT1	tRNA nucleotidyl transferase 1	2
<a href="#">8563</a>	THOC5	THO complex 5	2
<a href="#">9317</a>	PTER	phosphotriesterase related	2
<a href="#">1605</a>	DAG1	dystroglycan 1	2
<a href="#">83939</a>	EIF2A	eukaryotic translation initiation factor 2A	2
<a href="#">5877</a>	RABIF	RAB interacting factor	2
<a href="#">10923</a>	SUB1	SUB1 homolog, transcriptional regulator	2
<a href="#">387263</a>	C6orf120	chromosome 6 open reading frame 120	2
<a href="#">28972</a>	SPCS1	signal peptidase complex subunit 1	2
<a href="#">10463</a>	SLC30A9	solute carrier family 30 member 9	2
<a href="#">1974</a>	EIF4A2	eukaryotic translation initiation factor 4A2	2
<a href="#">6993</a>	DYNLT1	dynein light chain Tctex-type 1	2
<a href="#">285331</a>	CCDC66	coiled-coil domain containing 66	2
<a href="#">51691</a>	LSM8	LSM8 homolog, U6 small nuclear RNA associated	2
<a href="#">84274</a>	COQ5	coenzyme Q5, methyltransferase	2
<a href="#">9046</a>	DOK2	docking protein 2	2
<a href="#">80824</a>	DUSP16	dual specificity phosphatase 16	2
<a href="#">11186</a>	RASSF1	Ras association domain family member 1	2
<a href="#">9524</a>	TECR	trans-2,3-enoyl-CoA reductase	2
<a href="#">55909</a>	BIN3	bridging integrator 3	2
<a href="#">953</a>	ENTPD1	ectonucleoside triphosphate diphosphohydrolase 1	2
<a href="#">8530</a>	CST7	cystatin F	2
<a href="#">11269</a>	DDX19B	DEAD-box helicase 19B	2
<a href="#">8766</a>	RAB11A	RAB11A, member RAS oncogene family	2
<a href="#">25977</a>	NECAP1	NECAP endocytosis associated 1	2
<a href="#">2000</a>	ELF4	E74 like ETS transcription factor 4	2
<a href="#">11040</a>	PIM2	Pim-2 proto-oncogene, serine/threonine kinase	2
<a href="#">2585</a>	GALK2	galactokinase 2	2
<a href="#">144402</a>	CPNE8	copine 8	2
<a href="#">79139</a>	DERL1	derlin 1	2
<a href="#">80196</a>	RNF34	ring finger protein 34	2
<a href="#">11262</a>	SP140	SP140 nuclear body protein	2

<a href="#">55312</a>	RFK	riboflavin kinase	2
<a href="#">64854</a>	USP46	ubiquitin specific peptidase 46	2
<a href="#">387882</a>	C12orf75	chromosome 12 open reading frame 75	2
<a href="#">11270</a>	NRM	nurim (nuclear envelope membrane protein)	2
<a href="#">896</a>	CCND3	cyclin D3	2
<a href="#">143888</a>	KDEL2	KDEL motif containing 2	2
<a href="#">5008</a>	OSM	oncostatin M	2
<a href="#">10602</a>	CDC42EP3	CDC42 effector protein 3	2
<a href="#">54918</a>	CMTM6	CKLF like MARVEL transmembrane domain containing 6	2
<a href="#">1063</a>	CENPF	centromere protein F	2
<a href="#">84243</a>	ZDHHC18	zinc finger DHHC-type containing 18	2
<a href="#">382</a>	ARF6	ADP ribosylation factor 6	2
<a href="#">134266</a>	GRPEL2	GrpE like 2, mitochondrial	2
<a href="#">3001</a>	GZMA	granzyme A	2
<a href="#">6352</a>	CCL5	C-C motif chemokine ligand 5	2
<a href="#">55028</a>	C17orf80	chromosome 17 open reading frame 80	2
<a href="#">23258</a>	DENND5A	DENN domain containing 5A	2
<a href="#">56954</a>	NIT2	nitrilase family member 2	2
<a href="#">93621</a>	MRFAP1	Morf4 family associated protein 1	2
<a href="#">5347</a>	PLK1	polo like kinase 1	2
<a href="#">58190</a>	CTDSP1	CTD small phosphatase 1	2
<a href="#">2014</a>	EMP3	epithelial membrane protein 3	2
<a href="#">5269</a>	SERPINB6	serpin family B member 6	2
<a href="#">113802</a>	HENMT1	HEN1 methyltransferase homolog 1	2
<a href="#">10578</a>	GNLY	granulysin	2
<a href="#">5551</a>	PRF1	perforin 1	2
<a href="#">26610</a>	ELP4	elongator acetyltransferase complex subunit 4	2
<a href="#">9477</a>	MED20	mediator complex subunit 20	2
<a href="#">8634</a>	RTCA	RNA 3'-terminal phosphate cyclase	2
<a href="#">3428</a>	IFI16	interferon gamma inducible protein 16	2
<a href="#">63901</a>	FAM111A	family with sequence similarity 111 member A	2
<a href="#">55796</a>	MBNL3	muscleblind like splicing regulator 3	2
<a href="#">2177</a>	FANCD2	Fanconi anemia complementation group D2	3
<a href="#">86</a>	ACTL6A	actin like 6A	3
<a href="#">57696</a>	DDX55	DEAD-box helicase 55	3
<a href="#">54920</a>	DUS2	dihydrouridine synthase 2	3
<a href="#">22809</a>	ATF5	activating transcription factor 5	3
<a href="#">56052</a>	ALG1	ALG1, chitobiosyldiphosphodolichol beta-mannosyltransferase	3
<a href="#">51099</a>	ABHD5	abhydrolase domain containing 5	3
<a href="#">142940</a>	TRUB1	TruB pseudouridine synthase family member 1	3
<a href="#">23729</a>	SHPK	sedoheptulokinase	3
<a href="#">9016</a>	SLC25A14	solute carrier family 25 member 14	3
<a href="#">10352</a>	WARS2	tryptophanyl tRNA synthetase 2, mitochondrial	3
<a href="#">24140</a>	FTSJ1	FtsJ RNA methyltransferase homolog 1 (E. coli)	3
<a href="#">23463</a>	ICMT	isoprenylcysteine carboxyl methyltransferase	3
<a href="#">54974</a>	THG1L	tRNA-histidine guanylyltransferase 1 like	3
<a href="#">124808</a>	CCDC43	coiled-coil domain containing 43	3
<a href="#">5306</a>	PITPNA	phosphatidylinositol transfer protein alpha	3
<a href="#">643155</a>	SMIM15	small integral membrane protein 15	3
<a href="#">51260</a>	PBDC1	polysaccharide biosynthesis domain containing 1	3
<a href="#">10200</a>	MPHOSPH6	M-phase phosphoprotein 6	3
<a href="#">283578</a>	TMED8	transmembrane p24 trafficking protein family member 8	3
<a href="#">79154</a>	DHRS11	dehydrogenase/reductase 11	3
<a href="#">1743</a>	DLST	dihydroipoamide S-succinyltransferase	3
<a href="#">5277</a>	PIGA	phosphatidylinositol glycan anchor biosynthesis class A	3
<a href="#">995</a>	CDC25C	cell division cycle 25C	3
<a href="#">3833</a>	KIFC1	kinesin family member C1	3
<a href="#">1967</a>	EIF2B1	eukaryotic translation initiation factor 2B subunit alpha	3
<a href="#">119392</a>	SFR1	SWI5 dependent homologous recombination repair protein 1	3
<a href="#">55795</a>	PCID2	PCI domain containing 2	3
<a href="#">81542</a>	TMX1	thioredoxin related transmembrane protein 1	3
<a href="#">55215</a>	FANCI	Fanconi anemia complementation group I	3
<a href="#">23172</a>	FAM175B	family with sequence similarity 175 member B	3
<a href="#">5711</a>	PSMD5	proteasome 26S subunit, non-ATPase 5	3
<a href="#">153339</a>	TMEM167A	transmembrane protein 167A	3

<a href="#">3842</a>	TNPO1	transportin 1	3
<a href="#">84928</a>	TMEM209	transmembrane protein 209	3
<a href="#">51263</a>	MRPL30	mitochondrial ribosomal protein L30	3
<a href="#">7327</a>	UBE2G2	ubiquitin conjugating enzyme E2 G2	3
<a href="#">23169</a>	SLC35D1	solute carrier family 35 member D1	3
<a href="#">10617</a>	STAMBP	STAM binding protein	3
<a href="#">8697</a>	CDC23	cell division cycle 23	3
<a href="#">83930</a>	STARD3NL	STARD3 N-terminal like	3
<a href="#">54556</a>	ING3	inhibitor of growth family member 3	3
<a href="#">6185</a>	RPN2	ribophorin II	3
<a href="#">253558</a>	LCLAT1	lysocardiolipin acyltransferase 1	3
<a href="#">64710</a>	NUCKS1	nuclear casein kinase and cyclin dependent kinase substrate 1	3
<a href="#">1635</a>	DCTD	dCMP deaminase	3
<a href="#">91687</a>	CENPL	centromere protein L	3
<a href="#">55308</a>	DDX19A	DEAD-box helicase 19A	3
<a href="#">411</a>	ARSB	arylsulfatase B	3
<a href="#">5889</a>	RAD51C	RAD51 paralog C	3
<a href="#">7531</a>	YWHAE	tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein epsilon	3
<a href="#">79607</a>	FAM118B	family with sequence similarity 118 member B	3
<a href="#">8883</a>	NAE1	NEDD8 activating enzyme E1 subunit 1	3
<a href="#">2990</a>	GUSB	glucuronidase beta	3
<a href="#">4076</a>	CAPRN1	cell cycle associated protein 1	3
<a href="#">4841</a>	NONO	non-POU domain containing, octamer-binding	3
<a href="#">23511</a>	NUP188	nucleoporin 188	3
<a href="#">54811</a>	ZNF562	zinc finger protein 562	3
<a href="#">23279</a>	NUP160	nucleoporin 160	3
<a href="#">10146</a>	G3BP1	G3BP stress granule assembly factor 1	3
<a href="#">27085</a>	MTBP	MDM2 binding protein	3
<a href="#">23310</a>	NCAPD3	non-SMC condensin II complex subunit D3	3
<a href="#">6634</a>	SNRPD3	small nuclear ribonucleoprotein D3 polypeptide	3
<a href="#">10920</a>	COPS8	COP9 signalosome subunit 8	3
<a href="#">1678</a>	TIMM8A	translocase of inner mitochondrial membrane 8 homolog A (yeast)	3
<a href="#">1798</a>	DPAGT1	dolichyl-phosphate N-acetylglucosaminophosphotransferase 1	3
<a href="#">79135</a>	APOO	apolipoprotein O	3
<a href="#">3187</a>	HNRNPH1	heterogeneous nuclear ribonucleoprotein H1 (H)	3
<a href="#">89944</a>	GLB1L2	galactosidase beta 1 like 2	3
<a href="#">5096</a>	PCCB	propionyl-CoA carboxylase beta subunit	3
<a href="#">55254</a>	TMEM39A	transmembrane protein 39A	3
<a href="#">6341</a>	SCO1	SCO1, cytochrome c oxidase assembly protein	3
<a href="#">59067</a>	IL21	interleukin 21	3
<a href="#">166968</a>	MIER3	MIER family member 3	3
<a href="#">51524</a>	TMEM138	transmembrane protein 138	3
<a href="#">7555</a>	CNBP	CCHC-type zinc finger nucleic acid binding protein	3
<a href="#">57645</a>	POGK	pogo transposable element with KRAB domain	3
<a href="#">1622</a>	DBI	diazepam binding inhibitor, acyl-CoA binding protein	3
<a href="#">23741</a>	EID1	EP300 interacting inhibitor of differentiation 1	3
<a href="#">84881</a>	RPUSD4	RNA pseudouridylylase synthase domain containing 4	3
<a href="#">79868</a>	ALG13	ALG13, UDP-N-acetylglucosaminyltransferase subunit	3
<a href="#">10910</a>	SUGT1	SGT1 homolog, MIS12 kinetochore complex assembly cochaperone	3
<a href="#">6902</a>	TBCA	tubulin folding cofactor A	3
<a href="#">51094</a>	ADIPOR1	adiponectin receptor 1	3
<a href="#">54534</a>	MRPL50	mitochondrial ribosomal protein L50	3
<a href="#">5271</a>	SERPINB8	serpin family B member 8	3
<a href="#">51318</a>	MRPL35	mitochondrial ribosomal protein L35	3
<a href="#">9978</a>	RBX1	ring-box 1	3
<a href="#">5885</a>	RAD21	RAD21 cohesin complex component	3
<a href="#">9184</a>	BUB3	BUB3, mitotic checkpoint protein	3
<a href="#">25847</a>	ANAPC13	anaphase promoting complex subunit 13	3
<a href="#">25912</a>	C1orf43	chromosome 1 open reading frame 43	3
<a href="#">9025</a>	RNF8	ring finger protein 8	3
<a href="#">10959</a>	TMED2	transmembrane p24 trafficking protein 2	3
<a href="#">1070</a>	CETN3	centrin 3	3
<a href="#">7419</a>	VDAC3	voltage dependent anion channel 3	3
<a href="#">5356</a>	PLRG1	pleiotropic regulator 1	3
<a href="#">54529</a>	ASNSD1	asparagine synthetase domain containing 1	3

<a href="#">51441</a>	YTHDF2	YTH N6-methyladenosine RNA binding protein 2	3
<a href="#">5481</a>	PPID	peptidylprolyl isomerase D	3
<a href="#">23098</a>	SARM1	sterile alpha and TIR motif containing 1	3
<a href="#">22907</a>	DHX30	DEAH-box helicase 30	3
<a href="#">65220</a>	NADK	NAD kinase	3
<a href="#">201725</a>	C4orf46	chromosome 4 open reading frame 46	3
<a href="#">2241</a>	FER	FER tyrosine kinase	3
<a href="#">79598</a>	CEP97	centrosomal protein 97	3
<a href="#">23760</a>	PITPNB	phosphatidylinositol transfer protein beta	3
<a href="#">2965</a>	GTF2H1	general transcription factor IIH subunit 1	3
<a href="#">6392</a>	SDHD	succinate dehydrogenase complex subunit D	3
<a href="#">10001</a>	MED6	mediator complex subunit 6	3
<a href="#">24145</a>	PANX1	pannexin 1	3
<a href="#">26985</a>	AP3M1	adaptor related protein complex 3 mu 1 subunit	3
<a href="#">54853</a>	WDR55	WD repeat domain 55	3
<a href="#">9839</a>	ZEB2	zinc finger E-box binding homeobox 2	3
<a href="#">5710</a>	PSMD4	proteasome 26S subunit, non-ATPase 4	3
<a href="#">284695</a>	ZNF326	zinc finger protein 326	3
<a href="#">598</a>	BCL2L1	BCL2 like 1	3
<a href="#">29927</a>	SEC61A1	Sec61 translocon alpha 1 subunit	3
<a href="#">91368</a>	CDKN2AIPNL	CDKN2A interacting protein N-terminal like	3
<a href="#">51639</a>	SF3B6	splicing factor 3b subunit 6	3
<a href="#">10483</a>	SEC23B	Sec23 homolog B, coat complex II component	3
<a href="#">6732</a>	SRPK1	SRSF protein kinase 1	3
<a href="#">9412</a>	MED21	mediator complex subunit 21	3
<a href="#">80777</a>	CYB5B	cytochrome b5 type B	3
<a href="#">5861</a>	RAB1A	RAB1A, member RAS oncogene family	3
<a href="#">84191</a>	FAM96A	family with sequence similarity 96 member A	3
<a href="#">4710</a>	NDUFB4	NADH:ubiquinone oxidoreductase subunit B4	3
<a href="#">51538</a>	ZCCHC17	zinc finger CCHC-type containing 17	3
<a href="#">7385</a>	UQCRC2	ubiquinol-cytochrome c reductase core protein II	3
<a href="#">221443</a>	OARD1	O-acyl-ADP-ribose deacylase 1	3
<a href="#">55101</a>	ATP5SL	ATP5S like	3
<a href="#">51300</a>	TIMMDC1	translocase of inner mitochondrial membrane domain containing 1	3
<a href="#">375</a>	ARF1	ADP ribosylation factor 1	3
<a href="#">7979</a>	SHFM1	split hand/foot malformation (ectrodactyly) type 1	3
<a href="#">5706</a>	PSMC6	proteasome 26S subunit, ATPase 6	3
<a href="#">5092</a>	PCBD1	pterin-4 alpha-carbinolamine dehydratase 1	3
<a href="#">58517</a>	RBM25	RNA binding motif protein 25	3
<a href="#">10298</a>	PAK4	p21 (RAC1) activated kinase 4	3
<a href="#">91942</a>	NDUFAF2	NADH:ubiquinone oxidoreductase complex assembly factor 2	3
<a href="#">195827</a>	AAED1	AhpC/TSA antioxidant enzyme domain containing 1	3
<a href="#">2960</a>	GTF2E1	general transcription factor IIE subunit 1	3
<a href="#">509</a>	ATP5C1	ATP synthase, H+ transporting, mitochondrial F1 complex, gamma polypeptide 1	3
<a href="#">84268</a>	RPAIN	RPA interacting protein	3
<a href="#">8089</a>	YEATS4	YEATS domain containing 4	3
<a href="#">9416</a>	DDX23	DEAD-box helicase 23	3
<a href="#">466</a>	ATF1	activating transcription factor 1	3
<a href="#">55151</a>	TMEM38B	transmembrane protein 38B	3
<a href="#">84964</a>	ALKBH6	alkB homolog 6	3
<a href="#">84950</a>	PRPF38A	pre-mRNA processing factor 38A	3
<a href="#">64981</a>	MRPL34	mitochondrial ribosomal protein L34	3
<a href="#">1827</a>	RCAN1	regulator of calcineurin 1	3
<a href="#">51569</a>	UFM1	ubiquitin fold modifier 1	3
<a href="#">57117</a>	INTS12	integrator complex subunit 12	3
<a href="#">9588</a>	PRDX6	peroxiredoxin 6	3
<a href="#">28978</a>	TMEM14A	transmembrane protein 14A	3
<a href="#">7332</a>	UBE2L3	ubiquitin conjugating enzyme E2 L3	3
<a href="#">378</a>	ARF4	ADP ribosylation factor 4	3
<a href="#">51495</a>	HACD3	3-hydroxyacyl-CoA dehydratase 3	3
<a href="#">9555</a>	H2AFY	H2A histone family member Y	3
<a href="#">10635</a>	RAD51AP1	RAD51 associated protein 1	3
<a href="#">11198</a>	SUPT16H	SPT16 homolog, facilitates chromatin remodeling subunit	3
<a href="#">23595</a>	ORC3	origin recognition complex subunit 3	3
<a href="#">30009</a>	TBX21	T-box 21	3

<a href="#">5167</a>	ENPP1	ectonucleotide pyrophosphatase/phosphodiesterase 1	3
<a href="#">28987</a>	NOB1	NIN1/PSMD8 binding protein 1 homolog	3
<a href="#">7329</a>	UBE2I	ubiquitin conjugating enzyme E2 I	3
<a href="#">246184</a>	CDC26	cell division cycle 26	3
<a href="#">4712</a>	NDUFB6	NADH:ubiquinone oxidoreductase subunit B6	3
<a href="#">253782</a>	CERS6	ceramide synthase 6	3
<a href="#">11014</a>	KDELR2	KDEL endoplasmic reticulum protein retention receptor 2	3
<a href="#">56943</a>	ENY2	ENY2, transcription and export complex 2 subunit	3
<a href="#">440145</a>	MZT1	mitotic spindle organizing protein 1	3
<a href="#">84128</a>	WDR75	WD repeat domain 75	3
<a href="#">55660</a>	PRPF40A	pre-mRNA processing factor 40 homolog A	3
<a href="#">23322</a>	RPGRIP1L	RPGRIP1 like	3
<a href="#">3178</a>	HNRNPA1	heterogeneous nuclear ribonucleoprotein A1	3
<a href="#">9275</a>	BCL7B	BCL tumor suppressor 7B	3
<a href="#">65991</a>	FUNDC2	FUN14 domain containing 2	3
<a href="#">64794</a>	DDX31	DEAD-box helicase 31	3
<a href="#">8798</a>	DYRK4	dual specificity tyrosine phosphorylation regulated kinase 4	3
<a href="#">55315</a>	SLC29A3	solute carrier family 29 member 3	3
<a href="#">219541</a>	MED19	mediator complex subunit 19	3
<a href="#">729993</a>	SHISA9	shisa family member 9	3
<a href="#">8394</a>	PIP5K1A	phosphatidylinositol-4-phosphate 5-kinase type 1 alpha	3
<a href="#">93487</a>	MAPK1IP1L	mitogen-activated protein kinase 1 interacting protein 1 like	3
<a href="#">25994</a>	HIGD1A	HIG1 hypoxia inducible domain family member 1A	3
<a href="#">87178</a>	PNPT1	polyribonucleotide nucleotidyltransferase 1	3
<a href="#">6629</a>	SNRPB2	small nuclear ribonucleoprotein polypeptide B2	3
<a href="#">25879</a>	DCAF13	DDB1 and CUL4 associated factor 13	3
<a href="#">134430</a>	WDR36	WD repeat domain 36	3
<a href="#">23658</a>	LSM5	LSM5 homolog, U6 small nuclear RNA and mRNA degradation associated	3
<a href="#">9128</a>	PRPF4	pre-mRNA processing factor 4	3
<a href="#">8891</a>	EIF2B3	eukaryotic translation initiation factor 2B subunit gamma	3
<a href="#">10269</a>	ZMPSTE24	zinc metalloproteinase STE24	3
<a href="#">498</a>	ATP5A1	ATP synthase, H+ transporting, mitochondrial F1 complex, alpha subunit 1, cardiac muscle	3
<a href="#">1738</a>	DLD	dihydrolipoamide dehydrogenase	3
<a href="#">54332</a>	GDAP1	ganglioside induced differentiation associated protein 1	3
<a href="#">85465</a>	SELENOI	selenoprotein I	3
<a href="#">5701</a>	PSMC2	proteasome 26S subunit, ATPase 2	3
<a href="#">3035</a>	HARS	histidyl-tRNA synthetase	3
<a href="#">55361</a>	PI4K2A	phosphatidylinositol 4-kinase type 2 alpha	3
<a href="#">5687</a>	PSMA6	proteasome subunit alpha 6	3
<a href="#">23016</a>	EXOSC7	exosome component 7	3
<a href="#">214</a>	ALCAM	activated leukocyte cell adhesion molecule	3
<a href="#">2108</a>	ETFA	electron transfer flavoprotein alpha subunit	3
<a href="#">29960</a>	MRM2	mitochondrial rRNA methyltransferase 2	3
<a href="#">5690</a>	PSMB2	proteasome subunit beta 2	3
<a href="#">3735</a>	KARS	lysyl-tRNA synthetase	3
<a href="#">10666</a>	CD226	CD226 molecule	3
<a href="#">10237</a>	SLC35B1	solute carrier family 35 member B1	3
<a href="#">80218</a>	NAA50	N(alpha)-acetyltransferase 50, NatE catalytic subunit	3
<a href="#">57476</a>	GRAMD1B	GRAM domain containing 1B	3
<a href="#">10376</a>	TUBA1B	tubulin alpha 1b	3
<a href="#">11102</a>	RPP14	ribonuclease P/MRP subunit p14	3
<a href="#">11340</a>	EXOSC8	exosome component 8	3
<a href="#">6717</a>	SRI	sorcin	3
<a href="#">2395</a>	FXN	frataxin	3
<a href="#">8872</a>	CDC123	cell division cycle 123	3
<a href="#">8533</a>	COP3	COP9 signalosome subunit 3	3
<a href="#">79869</a>	CPSF7	cleavage and polyadenylation specific factor 7	3
<a href="#">493856</a>	CISD2	CDGSH iron sulfur domain 2	3
<a href="#">9319</a>	TRIP13	thyroid hormone receptor interactor 13	3
<a href="#">54927</a>	CHCHD3	coiled-coil-helix-coiled-coil-helix domain containing 3	3
<a href="#">10042</a>	HMGXB4	HMG-box containing 4	3
<a href="#">55787</a>	TXLNG	taxilin gamma	3
<a href="#">4522</a>	MTHFD1	methylenetetrahydrofolate dehydrogenase, cyclohydrolase and formyltetrahydrofolate synthetase 1	3

<a href="#">10007</a>	GNPDA1	glucosamine-6-phosphate deaminase 1	3
<a href="#">10229</a>	COQ7	coenzyme Q7, hydroxylase	3
<a href="#">2079</a>	ERH	enhancer of rudimentary homolog (Drosophila)	3
<a href="#">29796</a>	UQCR10	ubiquinol-cytochrome c reductase, complex III subunit X	3
<a href="#">5705</a>	PSMC5	proteasome 26S subunit, ATPase 5	3
<a href="#">128061</a>	C1orf131	chromosome 1 open reading frame 131	3
<a href="#">10284</a>	SAP18	Sin3A associated protein 18	3
<a href="#">3015</a>	H2AFZ	H2A histone family member Z	3
<a href="#">54957</a>	TXNL4B	thioredoxin like 4B	3
<a href="#">10944</a>	C11orf58	chromosome 11 open reading frame 58	3
<a href="#">23788</a>	MTCH2	mitochondrial carrier 2	3
<a href="#">6118</a>	RPA2	replication protein A2	3
<a href="#">65260</a>	COA7	cytochrome c oxidase assembly factor 7 (putative)	3
<a href="#">3419</a>	IDH3A	isocitrate dehydrogenase 3 (NAD(+)) alpha	3
<a href="#">285381</a>	DPH3	diphthamide biosynthesis 3	3
<a href="#">11103</a>	KRR1	KRR1, small subunit processome component homolog	3
<a href="#">56942</a>	CMC2	C-X9-C motif containing 2	3
<a href="#">5440</a>	POLR2K	RNA polymerase II subunit K	3
<a href="#">326625</a>	MMAB	methylmalonic aciduria (cobalamin deficiency) cblB type	3
<a href="#">23587</a>	ELP5	elongator acetyltransferase complex subunit 5	3
<a href="#">57129</a>	MRPL47	mitochondrial ribosomal protein L47	3
<a href="#">51202</a>	DDX47	DEAD-box helicase 47	3
<a href="#">80273</a>	GRPEL1	GrpE like 1, mitochondrial	3
<a href="#">79017</a>	GGCT	gamma-glutamylcyclotransferase	3
<a href="#">401505</a>	TOMM5	translocase of outer mitochondrial membrane 5	3
<a href="#">7353</a>	UFD1L	ubiquitin fusion degradation 1 like (yeast)	3
<a href="#">54205</a>	CYCS	cytochrome c, somatic	3
<a href="#">10289</a>	EIF1B	eukaryotic translation initiation factor 1B	3
<a href="#">124637</a>	CYB5D1	cytochrome b5 domain containing 1	3
<a href="#">27429</a>	HTRA2	HtrA serine peptidase 2	3
<a href="#">5691</a>	PSMB3	proteasome subunit beta 3	3
<a href="#">8683</a>	SRSF9	serine and arginine rich splicing factor 9	3
<a href="#">78996</a>	C7orf49	chromosome 7 open reading frame 49	3
<a href="#">81892</a>	SLIRP	SRA stem-loop interacting RNA binding protein	3
<a href="#">30968</a>	STOML2	stomatin like 2	3
<a href="#">55052</a>	MRPL20	mitochondrial ribosomal protein L20	3
<a href="#">441531</a>	PGAM4	phosphoglycerate mutase family member 4	3
<a href="#">7019</a>	TFAM	transcription factor A, mitochondrial	3
<a href="#">55239</a>	OGFOD1	2-oxoglutarate and iron dependent oxygenase domain containing 1	3
<a href="#">5515</a>	PPP2CA	protein phosphatase 2 catalytic subunit alpha	3
<a href="#">4361</a>	MRE11A	MRE11 homolog A, double strand break repair nuclease	3
<a href="#">5718</a>	PSMD12	proteasome 26S subunit, non-ATPase 12	3
<a href="#">4528</a>	MTIF2	mitochondrial translational initiation factor 2	3
<a href="#">10576</a>	CCT2	chaperonin containing TCP1 subunit 2	3
<a href="#">529</a>	ATP6V1E1	ATPase H+ transporting V1 subunit E1	3
<a href="#">150274</a>	HSCB	HscB mitochondrial iron-sulfur cluster cochaperone	3
<a href="#">140609</a>	NEK7	NIMA related kinase 7	3
<a href="#">113444</a>	SMIM12	small integral membrane protein 12	3
<a href="#">10197</a>	PSME3	proteasome activator subunit 3	3
<a href="#">152519</a>	NIPAL1	NIPA like domain containing 1	3
<a href="#">506</a>	ATP5B	ATP synthase, H+ transporting, mitochondrial F1 complex, beta polypeptide	3
<a href="#">5692</a>	PSMB4	proteasome subunit beta 4	3
<a href="#">92400</a>	RBM18	RNA binding motif protein 18	3
<a href="#">5110</a>	PCMT1	protein-L-isoaspartate (D-aspartate) O-methyltransferase	3
<a href="#">10480</a>	EIF3M	eukaryotic translation initiation factor 3 subunit M	3
<a href="#">4520</a>	MTF1	metal regulatory transcription factor 1	3
<a href="#">526</a>	ATP6V1B2	ATPase H+ transporting V1 subunit B2	3
<a href="#">7319</a>	UBE2A	ubiquitin conjugating enzyme E2 A	3
<a href="#">4836</a>	NMT1	N-myristoyltransferase 1	3
<a href="#">54470</a>	ARMCX6	armadillo repeat containing, X-linked 6	3
<a href="#">56852</a>	RAD18	RAD18, E3 ubiquitin protein ligase	3
<a href="#">10436</a>	EMG1	EMG1, N1-specific pseudouridine methyltransferase	3
<a href="#">4704</a>	NDUFA9	NADH:ubiquinone oxidoreductase subunit A9	3
<a href="#">27257</a>	LSM1	LSM1 homolog, mRNA degradation associated	3
<a href="#">79719</a>	AAGAB	alpha- and gamma-adaptin binding protein	3
<a href="#">25904</a>	CNOT10	CCR4-NOT transcription complex subunit 10	3

<a href="#">8892</a>	EIF2B2	eukaryotic translation initiation factor 2B subunit beta	3
<a href="#">892</a>	CCNC	cyclin C	3
<a href="#">169200</a>	TMEM64	transmembrane protein 64	3
<a href="#">56984</a>	PSMG2	proteasome assembly chaperone 2	3
<a href="#">223</a>	ALDH9A1	aldehyde dehydrogenase 9 family member A1	3
<a href="#">9330</a>	GTF3C3	general transcription factor IIIC subunit 3	3
<a href="#">6184</a>	RPN1	ribophorin I	3
<a href="#">116228</a>	COX20	COX20, cytochrome c oxidase assembly factor	3
<a href="#">9967</a>	THRAP3	thyroid hormone receptor associated protein 3	3
<a href="#">4725</a>	NDUFS5	NADH:ubiquinone oxidoreductase subunit S5	3
<a href="#">80135</a>	RPF1	ribosome production factor 1 homolog	3
<a href="#">5501</a>	PPP1CC	protein phosphatase 1 catalytic subunit gamma	3
<a href="#">28511</a>	NKIRAS2	NFKB inhibitor interacting Ras like 2	3
<a href="#">51234</a>	EMC4	ER membrane protein complex subunit 4	3
<a href="#">10671</a>	DCTN6	dynactin subunit 6	3
<a href="#">2631</a>	GBAS	glioblastoma amplified sequence	3
<a href="#">23306</a>	NEMP1	nuclear envelope integral membrane protein 1	3
<a href="#">10799</a>	RPP40	ribonuclease P/MRP subunit p40	3
<a href="#">57563</a>	KLHL8	kelch like family member 8	3
<a href="#">328</a>	APEX1	apurinic/aprimidinic endodeoxyribonuclease 1	3
<a href="#">90701</a>	SEC11C	SEC11 homolog C, signal peptidase complex subunit	3
<a href="#">23480</a>	SEC61G	Sec61 translocon gamma subunit	3
<a href="#">8819</a>	SAP30	Sin3A associated protein 30	3
<a href="#">52</a>	ACP1	acid phosphatase 1, soluble	3
<a href="#">1349</a>	COX7B	cytochrome c oxidase subunit 7B	3
<a href="#">7386</a>	UQCRCF51	ubiquinol-cytochrome c reductase, Rieske iron-sulfur polypeptide 1	3
<a href="#">26355</a>	FAM162A	family with sequence similarity 162 member A	3
<a href="#">29074</a>	MRPL18	mitochondrial ribosomal protein L18	3
<a href="#">79036</a>	KXD1	KxDL motif containing 1	3
<a href="#">26156</a>	RSL1D1	ribosomal L1 domain containing 1	3
<a href="#">55505</a>	NOP10	NOP10 ribonucleoprotein	3
<a href="#">522</a>	ATP5J	ATP synthase, H+ transporting, mitochondrial Fo complex subunit F6	3
<a href="#">387521</a>	TMEM189	transmembrane protein 189	3
<a href="#">5547</a>	PRCP	prolylcarboxypeptidase	3
<a href="#">26995</a>	TRUB2	TruB pseudouridine synthase family member 2	3
<a href="#">153527</a>	ZMAT2	zinc finger matrin-type 2	3
<a href="#">84126</a>	ATRIP	ATR interacting protein	3
<a href="#">201931</a>	TMEM192	transmembrane protein 192	3
<a href="#">4719</a>	NDUFS1	NADH:ubiquinone oxidoreductase core subunit S1	3
<a href="#">27095</a>	TRAPPC3	trafficking protein particle complex 3	3
<a href="#">9217</a>	VAPB	VAMP associated protein B and C	3
<a href="#">10548</a>	TM9SF1	transmembrane 9 superfamily member 1	3
<a href="#">55110</a>	MAGOHB	mago homolog B, exon junction complex core component	3
<a href="#">9512</a>	PMPCB	peptidase, mitochondrial processing beta subunit	3
<a href="#">58505</a>	OSTC	oligosaccharyltransferase complex non-catalytic subunit	3
<a href="#">55071</a>	C9orf40	chromosome 9 open reading frame 40	3
<a href="#">29086</a>	BABAM1	BRISC and BRCA1 A complex member 1	3
<a href="#">327</a>	APEH	acylaminoacyl-peptide hydrolase	3
<a href="#">221120</a>	ALKBH3	alkB homolog 3, alpha-ketoglutaratedependent dioxygenase	3
<a href="#">79109</a>	MAPKAP1	mitogen-activated protein kinase associated protein 1	3
<a href="#">375444</a>	C5orf34	chromosome 5 open reading frame 34	3
<a href="#">113829</a>	SLC35A4	solute carrier family 35 member A4	3
<a href="#">8350</a>	HIST1H3A	histone cluster 1 H3 family member a	3
<a href="#">79760</a>	GEMIN7	gem nuclear organelle associated protein 7	3
<a href="#">79002</a>	C19orf43	chromosome 19 open reading frame 43	3
<a href="#">8407</a>	TAGLN2	transgelin 2	3
<a href="#">5805</a>	PTS	6-pyruvoyltetrahydropterin synthase	3
<a href="#">8226</a>	PUDP	pseudouridine 5'-phosphatase	3
<a href="#">8330</a>	HIST1H2AK	histone cluster 1 H2A family member k	3
<a href="#">6944</a>	VPS72	vacuolar protein sorting 72 homolog	3
<a href="#">22913</a>	RALY	RALY heterogeneous nuclear ribonucleoprotein	3
<a href="#">9793</a>	CKAP5	cytoskeleton associated protein 5	3
<a href="#">11065</a>	UBE2C	ubiquitin conjugating enzyme E2 C	3
<a href="#">81605</a>	URM1	ubiquitin related modifier 1	3
<a href="#">6388</a>	SDF2	stromal cell derived factor 2	3

<a href="#">8970</a>	HIST1H2BJ	histone cluster 1 H2B family member j	3
<a href="#">8345</a>	HIST1H2BH	histone cluster 1 H2B family member h	3
<a href="#">2491</a>	CENPI	centromere protein I	3
<a href="#">5090</a>	PBX3	PBX homeobox 3	3
<a href="#">24137</a>	KIF4A	kinesin family member 4A	3
<a href="#">50943</a>	FOXP3	forkhead box P3	3
<a href="#">8346</a>	HIST1H2BI	histone cluster 1 H2B family member i	3
<a href="#">8357</a>	HIST1H3H	histone cluster 1 H3 family member h	3
<a href="#">8368</a>	HIST1H4L	histone cluster 1 H4 family member l	3
<a href="#">8355</a>	HIST1H3G	histone cluster 1 H3 family member g	3
<a href="#">8348</a>	HIST1H2BO	histone cluster 1 H2B family member o	3
<a href="#">734</a>	OSGIN2	oxidative stress induced growth inhibitor family member 2	3
<a href="#">968</a>	CD68	CD68 molecule	3
<a href="#">11004</a>	KIF2C	kinesin family member 2C	3
<a href="#">80222</a>	TARS2	threonyl-tRNA synthetase 2, mitochondrial (putative)	3
<a href="#">81603</a>	TRIM8	tripartite motif containing 8	3
<a href="#">123606</a>	NIPA1	non imprinted in Prader-Willi/Angelman syndrome 1	3
<a href="#">6046</a>	BRD2	bromodomain containing 2	3
<a href="#">3006</a>	HIST1H1C	histone cluster 1 H1 family member c	3
<a href="#">29916</a>	SNX11	sorting nexin 11	3
<a href="#">9817</a>	KEAP1	kelch like ECH associated protein 1	3
<a href="#">3996</a>	LLGL1	LLGL1, scribble cell polarity complex component	3
<a href="#">5827</a>	PXMP2	peroxisomal membrane protein 2	3
<a href="#">318</a>	NUDT2	nudix hydrolase 2	3
<a href="#">117177</a>	RAB3IP	RAB3A interacting protein	3
<a href="#">80227</a>	PAAF1	proteasomal ATPase associated factor 1	3
<a href="#">116064</a>	LRRCS8	leucine rich repeat containing 58	3
<a href="#">56890</a>	MDM1	Mdm1 nuclear protein	3
<a href="#">84058</a>	WDR54	WD repeat domain 54	3
<a href="#">4087</a>	SMAD2	SMAD family member 2	3
<a href="#">899</a>	CCNF	cyclin F	3
<a href="#">8349</a>	HIST2H2BE	histone cluster 2 H2B family member e	3
<a href="#">84193</a>	SETD3	SET domain containing 3	3
<a href="#">140901</a>	STK35	serine/threonine kinase 35	3
<a href="#">55704</a>	CCDC88A	coiled-coil domain containing 88A	3
<a href="#">23132</a>	RAD54L2	RAD54-like 2 (S. cerevisiae)	3
<a href="#">56672</a>	AKIP1	A-kinase interacting protein 1	3
<a href="#">11218</a>	DDX20	DEAD-box helicase 20	3
<a href="#">27291</a>	R3HCC1L	R3H domain and coiled-coil containing 1 like	3
<a href="#">874</a>	CBR3	carbonyl reductase 3	3
<a href="#">84959</a>	UBASH3B	ubiquitin associated and SH3 domain containing B	3
<a href="#">10134</a>	BCAP31	B-cell receptor-associated protein 31	3
<a href="#">4968</a>	OGG1	8-oxoguanine DNA glycosylase	3
<a href="#">415116</a>	PIM3	Pim-3 proto-oncogene, serine/threonine kinase	3
<a href="#">80199</a>	FUZ	fuzzy planar cell polarity protein	3
<a href="#">967</a>	CD63	CD63 molecule	3
<a href="#">84232</a>	MAF1	MAF1 homolog, negative regulator of RNA polymerase III	3
<a href="#">572</a>	BAD	BCL2 associated agonist of cell death	3
<a href="#">26608</a>	TBL2	transducin beta like 2	3
<a href="#">5538</a>	PPT1	palmitoyl-protein thioesterase 1	3
<a href="#">3008</a>	HIST1H1E	histone cluster 1 H1 family member e	3
<a href="#">65062</a>	TMEM237	transmembrane protein 237	3
<a href="#">8294</a>	HIST1H4I	histone cluster 1 H4 family member i	3
<a href="#">8335</a>	HIST1H2AB	histone cluster 1 H2A family member b	3
<a href="#">3024</a>	HIST1H1A	histone cluster 1 H1 family member a	3
<a href="#">439</a>	ASNA1	arsA arsenite transporter, ATP-binding, homolog 1 (bacterial)	3
<a href="#">2805</a>	GOT1	glutamic-oxaloacetic transaminase 1	3
<a href="#">57539</a>	WDR35	WD repeat domain 35	3
<a href="#">163786</a>	SASS6	SAS-6 centriolar assembly protein	3
<a href="#">3189</a>	HNRNPH3	heterogeneous nuclear ribonucleoprotein H3	3
<a href="#">85236</a>	HIST1H2BK	histone cluster 1 H2B family member k	3
<a href="#">5881</a>	RAC3	ras-related C3 botulinum toxin substrate 3 (rho family, small GTP binding protein Rac3)	3
<a href="#">10614</a>	HEXIM1	hexamethylene bisacetamide inducible 1	3
<a href="#">283464</a>	GXYLT1	glucoside xylosyltransferase 1	3

<a href="#">3014</a>	H2AFX	H2A histone family member X	3
<a href="#">25853</a>	DCAF12	DDB1 and CUL4 associated factor 12	3
<a href="#">56994</a>	CHPT1	choline phosphotransferase 1	3
<a href="#">9551</a>	ATP5J2	ATP synthase, H+ transporting, mitochondrial Fo complex subunit F2	3
<a href="#">27304</a>	MOCS3	molybdenum cofactor synthesis 3	3
<a href="#">113130</a>	CDCA5	cell division cycle associated 5	3
<a href="#">81887</a>	LAS1L	LAS1 like, ribosome biogenesis factor	3
<a href="#">5201</a>	PFDN1	prefoldin subunit 1	3
<a href="#">91057</a>	CCDC34	coiled-coil domain containing 34	3
<a href="#">468</a>	ATF4	activating transcription factor 4	3
<a href="#">161823</a>	ADAL	adenosine deaminase like	3
<a href="#">55723</a>	ASF1B	anti-silencing function 1B histone chaperone	3
<a href="#">91442</a>	FAAP24	Fanconi anemia core complex associated protein 24	3
<a href="#">220002</a>	CYB561A3	cytochrome b561 family member A3	3
<a href="#">84759</a>	PCGF1	polycomb group ring finger 1	3
<a href="#">112950</a>	MED8	mediator complex subunit 8	3
<a href="#">587</a>	BCAT2	branched chain amino acid transaminase 2	3
<a href="#">643</a>	CXCR5	C-X-C motif chemokine receptor 5	3
<a href="#">55794</a>	DDX28	DEAD-box helicase 28	3
<a href="#">6470</a>	SHMT1	serine hydroxymethyltransferase 1	3
<a href="#">10651</a>	MTX2	metaxin 2	3
<a href="#">54921</a>	CHTF8	chromosome transmission fidelity factor 8	3
<a href="#">51283</a>	BFAR	bifunctional apoptosis regulator	3
<a href="#">57456</a>	KIAA1143	KIAA1143	3
<a href="#">54995</a>	OXSM	3-oxoacyl-ACP synthase, mitochondrial	3
<a href="#">79102</a>	RNF26	ring finger protein 26	3
<a href="#">79000</a>	AUNIP	aurora kinase A and ninein interacting protein	3
<a href="#">4947</a>	OAZ2	ornithine decarboxylase antizyme 2	3
<a href="#">25979</a>	DHRS7B	dehydrogenase/reductase 7B	3
<a href="#">23052</a>	ENDOD1	endonuclease domain containing 1	3
<a href="#">728568</a>	C12orf73	chromosome 12 open reading frame 73	3
<a href="#">54890</a>	ALKBH5	alkB homolog 5, RNA demethylase	3
<a href="#">348793</a>	WDR53	WD repeat domain 53	3
<a href="#">57045</a>	TWSG1	twisted gastrulation BMP signaling modulator 1	3
<a href="#">84844</a>	PHF5A	PHD finger protein 5A	3
<a href="#">79228</a>	THOC6	THO complex 6	3
<a href="#">27235</a>	COQ2	coenzyme Q2, polyprenyltransferase	3
<a href="#">170371</a>	C10orf128	chromosome 10 open reading frame 128	3
<a href="#">1861</a>	TOR1A	torsin family 1 member A	3
<a href="#">150771</a>	ITPR1L1	inositol 1,4,5-trisphosphate receptor interacting protein-like 1	3
<a href="#">56180</a>	MOSPD1	motile sperm domain containing 1	3
<a href="#">4702</a>	NDUFA8	NADH:ubiquinone oxidoreductase subunit A8	3
<a href="#">55246</a>	CCDC25	coiled-coil domain containing 25	3
<a href="#">5684</a>	PSMA3	proteasome subunit alpha 3	3
<a href="#">54942</a>	FAM206A	family with sequence similarity 206 member A	3
<a href="#">9836</a>	LCMT2	leucine carboxyl methyltransferase 2	3
<a href="#">55344</a>	PLCXD1	phosphatidylinositol specific phospholipase C X domain containing 1	3
<a href="#">49854</a>	ZBTB21	zinc finger and BTB domain containing 21	3
<a href="#">25926</a>	NOL11	nucleolar protein 11	3
<a href="#">1854</a>	DUT	deoxyuridine triphosphatase	3
<a href="#">662</a>	BNIP1	BCL2 interacting protein 1	3
<a href="#">29928</a>	TIMM22	translocase of inner mitochondrial membrane 22 homolog	3
<a href="#">78988</a>	MRPL57	mitochondrial ribosomal protein L57	3
<a href="#">121642</a>	ALKBH2	alkB homolog 2, alpha-ketoglutarate dependent dioxygenase	3
<a href="#">10535</a>	RNASEH2A	ribonuclease H2 subunit A	3
<a href="#">339230</a>	CCDC137	coiled-coil domain containing 137	3
<a href="#">51399</a>	TRAPPC4	trafficking protein particle complex 4	3
<a href="#">23239</a>	PHLPP1	PH domain and leucine rich repeat protein phosphatase 1	3
<a href="#">23212</a>	RRS1	ribosome biogenesis regulator homolog	3
<a href="#">26520</a>	TIMM9	translocase of inner mitochondrial membrane 9	3
<a href="#">84879</a>	MFS2A	major facilitator superfamily domain containing 2A	3
<a href="#">28973</a>	MRPS18B	mitochondrial ribosomal protein S18B	3
<a href="#">118472</a>	ZNF511	zinc finger protein 511	3
<a href="#">8531</a>	YBX3	Y-box binding protein 3	3
<a href="#">746</a>	TMEM258	transmembrane protein 258	3

<a href="#">147007</a>	TMEM199	transmembrane protein 199	3
<a href="#">55829</a>	SELENOS	selenoprotein S	3
<a href="#">23478</a>	SEC11A	SEC11 homolog A, signal peptidase complex subunit	3
<a href="#">5713</a>	PSMD7	proteasome 26S subunit, non-ATPase 7	3
<a href="#">65005</a>	MRPL9	mitochondrial ribosomal protein L9	3
<a href="#">27301</a>	APEX2	apurinic/aprimidinic endodeoxyribonuclease 2	3
<a href="#">27315</a>	PGAP2	post-GPI attachment to proteins 2	3
<a href="#">27075</a>	TSPAN13	tetraspanin 13	3
<a href="#">6396</a>	SEC13	SEC13 homolog, nuclear pore and COPII coat complex component	3
<a href="#">29101</a>	SSU72	SSU72 homolog, RNA polymerase II CTD phosphatase	3
<a href="#">79035</a>	NABP2	nucleic acid binding protein 2	3
<a href="#">5160</a>	PDHA1	pyruvate dehydrogenase (lipoamide) alpha 1	3
<a href="#">115416</a>	MALSU1	mitochondrial assembly of ribosomal large subunit 1	3
<a href="#">9218</a>	VAPA	VAMP associated protein A	3
<a href="#">3396</a>	MRPL58	mitochondrial ribosomal protein L58	3
<a href="#">64976</a>	MRPL40	mitochondrial ribosomal protein L40	3
<a href="#">1123</a>	CHN1	chimerin 1	3
<a href="#">149603</a>	RNF187	ring finger protein 187	3
<a href="#">84246</a>	MED10	mediator complex subunit 10	3
<a href="#">7260</a>	TSSC1	tumor suppressing subtransferable candidate 1	3
<a href="#">10084</a>	PQBP1	polyglutamine binding protein 1	3
<a href="#">661</a>	POLR3D	RNA polymerase III subunit D	3
<a href="#">56257</a>	MEPCE	methylphosphate capping enzyme	3
<a href="#">9371</a>	KIF3B	kinesin family member 3B	3
<a href="#">92002</a>	FAM58A	family with sequence similarity 58 member A	3
<a href="#">114049</a>	WBSCR22	Williams-Beuren syndrome chromosome region 22	3
<a href="#">55038</a>	CDCA4	cell division cycle associated 4	3
<a href="#">339263</a>	C17orf51	chromosome 17 open reading frame 51	3
<a href="#">11137</a>	PWP1	PWP1 homolog, endonuclease	3
<a href="#">55278</a>	QRSL1	glutamyl-tRNA synthase (glutamine-hydrolyzing)-like 1	3
<a href="#">8811</a>	GALR2	galanin receptor 2	3
<a href="#">118424</a>	UBE2J2	ubiquitin conjugating enzyme E2 J2	3
<a href="#">3596</a>	IL13	interleukin 13	3
<a href="#">7918</a>	GPANK1	G-patch domain and ankyrin repeats 1	3
<a href="#">376267</a>	RAB15	RAB15, member RAS oncogene family	3
<a href="#">8754</a>	ADAM9	ADAM metallopeptidase domain 9	3
<a href="#">22916</a>	NCBP2	nuclear cap binding protein subunit 2	3
<a href="#">79172</a>	CENPO	centromere protein O	3
<a href="#">84547</a>	PGBD1	piggyBac transposable element derived 1	3
<a href="#">28960</a>	DCPS	decapping enzyme, scavenger	3
<a href="#">10741</a>	RBBP9	RB binding protein 9, serine hydrolase	3
<a href="#">283106</a>	CSNK2A3	casein kinase 2 alpha 3	3
<a href="#">84065</a>	TMEM222	transmembrane protein 222	3
<a href="#">5686</a>	PSMA5	proteasome subunit alpha 5	3
<a href="#">6573</a>	SLC19A1	solute carrier family 19 member 1	3
<a href="#">51634</a>	RBMX2	RNA binding motif protein, X-linked 2	3
<a href="#">54802</a>	TRIT1	tRNA isopentenyltransferase 1	3
<a href="#">10280</a>	SIGMAR1	sigma non-opioid intracellular receptor 1	3
<a href="#">5496</a>	PPM1G	protein phosphatase, Mg <sup>2+</sup> /Mn <sup>2+</sup> dependent 1G	3
<a href="#">970</a>	CD70	CD70 molecule	3
<a href="#">9289</a>	ADGRG1	adhesion G protein-coupled receptor G1	3
<a href="#">115939</a>	TSR3	TSR3, acp transferase ribosome maturation factor	3
<a href="#">550</a>	AUP1	ancient ubiquitous protein 1	3
<a href="#">9560</a>	CCL4L2	C-C motif chemokine ligand 4 like 2	3
<a href="#">3567</a>	IL5	interleukin 5	3
<a href="#">91319</a>	DERL3	derlin 3	3
<a href="#">5743</a>	PTGS2	prostaglandin-endoperoxide synthase 2	3
<a href="#">3703</a>	STT3A	STT3A, catalytic subunit of the oligosaccharyltransferase complex	3
<a href="#">118980</a>	SFXN2	sideroflexin 2	3
<a href="#">3578</a>	IL9	interleukin 9	3
<a href="#">10276</a>	NET1	neuroepithelial cell transforming 1	3
<a href="#">6348</a>	CCL3	C-C motif chemokine ligand 3	3
<a href="#">10201</a>	NME6	NME/NM23 nucleoside diphosphate kinase 6	3
<a href="#">84296</a>	GINS4	GINS complex subunit 4	3
<a href="#">200933</a>	FBXO45	F-box protein 45	3

<a href="#">9050</a>	PSTPIP2	proline-serine-threonine phosphatase interacting protein 2	3
<a href="#">8356</a>	HIST1H3J	histone cluster 1 H3 family member j	3
<a href="#">64745</a>	METTL17	methyltransferase like 17	3
<a href="#">53838</a>	C11orf24	chromosome 11 open reading frame 24	3
<a href="#">10293</a>	TRAIIP	TRAF interacting protein	3
<a href="#">51023</a>	MRPS18C	mitochondrial ribosomal protein S18C	3
<a href="#">26150</a>	RIBC2	RIB43A domain with coiled-coils 2	3
<a href="#">4049</a>	LTA	lymphotoxin alpha	3
<a href="#">25828</a>	TXN2	thioredoxin 2	3
<a href="#">5886</a>	RAD23A	RAD23 homolog A, nucleotide excision repair protein	3
<a href="#">84522</a>	JAGN1	jagunal homolog 1	3
<a href="#">128178</a>	EDARADD	EDAR associated death domain	3
<a href="#">51163</a>	DBR1	debranching RNA lariats 1	3
<a href="#">84545</a>	MRPL43	mitochondrial ribosomal protein L43	3
<a href="#">84311</a>	MRPL45	mitochondrial ribosomal protein L45	3
<a href="#">132720</a>	C4orf32	chromosome 4 open reading frame 32	3
<a href="#">3775</a>	KCNK1	potassium two pore domain channel subfamily K member 1	3
<a href="#">54069</a>	MIS18A	MIS18 kinetochore protein A	3
<a href="#">55255</a>	WDR41	WD repeat domain 41	3
<a href="#">9334</a>	B4GALT5	beta-1,4-galactosyltransferase 5	3
<a href="#">80262</a>	C16orf70	chromosome 16 open reading frame 70	3
<a href="#">55122</a>	AKIRIN2	akirin 2	3
<a href="#">81610</a>	FAM83D	family with sequence similarity 83 member D	3
<a href="#">55116</a>	TMEM39B	transmembrane protein 39B	3
<a href="#">7976</a>	FZD3	frizzled class receptor 3	3
<a href="#">83693</a>	HSDL1	hydroxysteroid dehydrogenase like 1	3
<a href="#">5571</a>	PRKAG1	protein kinase AMP-activated non-catalytic subunit gamma 1	3
<a href="#">6839</a>	SUV39H1	suppressor of variegation 3-9 homolog 1	3
<a href="#">3052</a>	HCCS	holocytochrome c synthase	3
<a href="#">1435</a>	CSF1	colony stimulating factor 1	3
<a href="#">4682</a>	NUBP1	nucleotide binding protein 1	3
<a href="#">873</a>	CBR1	carbonyl reductase 1	3
<a href="#">4605</a>	MYBL2	MYB proto-oncogene like 2	3
<a href="#">84057</a>	MND1	meiotic nuclear divisions 1	3
<a href="#">2617</a>	GARS	glycyl-tRNA synthetase	3
<a href="#">55148</a>	UBR7	ubiquitin protein ligase E3 component n-recognin 7 (putative)	3
<a href="#">6241</a>	RRM2	ribonucleotide reductase regulatory subunit M2	3
<a href="#">91801</a>	ALKBH8	alkB homolog 8, tRNA methyltransferase	3
<a href="#">195828</a>	ZNF367	zinc finger protein 367	3
<a href="#">54541</a>	DDIT4	DNA damage inducible transcript 4	3
<a href="#">4292</a>	MLH1	mutL homolog 1	3
<a href="#">9837</a>	GINS1	GINS complex subunit 1	3
<a href="#">27000</a>	DNAJ2	DnaJ heat shock protein family (Hsp40) member C2	3
<a href="#">55005</a>	RMND1	required for meiotic nuclear division 1 homolog	3
<a href="#">5715</a>	PSMD9	proteasome 26S subunit, non-ATPase 9	3
<a href="#">220134</a>	SKA1	spindle and kinetochore associated complex subunit 1	3
<a href="#">55322</a>	C5orf22	chromosome 5 open reading frame 22	3
<a href="#">890</a>	CCNA2	cyclin A2	3
<a href="#">9833</a>	MELK	maternal embryonic leucine zipper kinase	3
<a href="#">64151</a>	NCAPG	non-SMC condensin I complex subunit G	3
<a href="#">4860</a>	PNP	purine nucleoside phosphorylase	3
<a href="#">8846</a>	ALKBH1	alkB homolog 1, histone H2A dioxygenase	3
<a href="#">23397</a>	NCAPH	non-SMC condensin I complex subunit H	3
<a href="#">79733</a>	E2F8	E2F transcription factor 8	3
<a href="#">55872</a>	PBK	PDZ binding kinase	3
<a href="#">11079</a>	RER1	retention in endoplasmic reticulum sorting receptor 1	3
<a href="#">51290</a>	ERGIC2	ERGIC and golgi 2	3
<a href="#">6729</a>	SRP54	signal recognition particle 54	3
<a href="#">121441</a>	NEDD1	neural precursor cell expressed, developmentally down-regulated 1	3
<a href="#">983</a>	CDK1	cyclin dependent kinase 1	3
<a href="#">6734</a>	SRPRA	SRP receptor alpha subunit	3
<a href="#">10438</a>	C1D	C1D nuclear receptor corepressor	3
<a href="#">11212</a>	PROSC	proline synthetase cotranscribed homolog (bacterial)	3
<a href="#">79023</a>	NUP37	nucleoporin 37	3
<a href="#">54433</a>	GAR1	GAR1 ribonucleoprotein	3

<a href="#">6504</a>	SLAMF1	signaling lymphocytic activation molecule family member 1	3
<a href="#">23107</a>	MRPS27	mitochondrial ribosomal protein S27	3
<a href="#">9585</a>	KIF20B	kinesin family member 20B	3
<a href="#">959</a>	CD40LG	CD40 ligand	3
<a href="#">4218</a>	RAB8A	RAB8A, member RAS oncogene family	3
<a href="#">23549</a>	DNPEP	aspartyl aminopeptidase	3
<a href="#">7272</a>	TTK	TTK protein kinase	3
<a href="#">84920</a>	ALG10	ALG10, alpha-1,2-glucosyltransferase	3
<a href="#">2218</a>	FKTN	fukutin	3
<a href="#">1786</a>	DNMT1	DNA methyltransferase 1	3
<a href="#">29078</a>	NDUFAF4	NADH:ubiquinone oxidoreductase complex assembly factor 4	3
<a href="#">144455</a>	E2F7	E2F transcription factor 7	3
<a href="#">25983</a>	NGDN	neuroguidin	3
<a href="#">11051</a>	NUDT21	nudix hydrolase 21	3
<a href="#">6426</a>	SRSF1	serine and arginine rich splicing factor 1	3
<a href="#">348995</a>	NUP43	nucleoporin 43	3
<a href="#">81556</a>	VWA9	von Willebrand factor A domain containing 9	3
<a href="#">286826</a>	LIN9	lin-9 DREAM MuvB core complex component	3
<a href="#">10615</a>	SPAG5	sperm associated antigen 5	3
<a href="#">10721</a>	POLQ	DNA polymerase theta	3
<a href="#">25800</a>	SLC39A6	solute carrier family 39 member 6	3
<a href="#">26958</a>	COPG2	coatomer protein complex subunit gamma 2	3
<a href="#">5894</a>	RAF1	Raf-1 proto-oncogene, serine/threonine kinase	3
<a href="#">8669</a>	EIF3J	eukaryotic translation initiation factor 3 subunit J	3
<a href="#">9131</a>	AIFM1	apoptosis inducing factor, mitochondria associated 1	3
<a href="#">28969</a>	BZW2	basic leucine zipper and W2 domains 2	3
		ribosomal RNA processing 9, small subunit (SSU) processome component, homolog (yeast)	3
<a href="#">9136</a>	RRP9		3
<a href="#">11033</a>	ADAP1	ArfGAP with dual PH domains 1	3
<a href="#">9377</a>	COX5A	cytochrome c oxidase subunit 5A	3
<a href="#">51103</a>	NDUFAF1	NADH:ubiquinone oxidoreductase complex assembly factor 1	3
<a href="#">196264</a>	MPZL3	myelin protein zero like 3	3
<a href="#">83732</a>	RIOK1	RIO kinase 1	3
<a href="#">116092</a>	DNTTIP1	deoxynucleotidyltransferase terminal interacting protein 1	3
<a href="#">8480</a>	RAE1	ribonucleic acid export 1	3
<a href="#">9556</a>	C14orf2	chromosome 14 open reading frame 2	3
<a href="#">403</a>	ARL3	ADP ribosylation factor like GTPase 3	3
<a href="#">10542</a>	LAMTOR5	late endosomal/lysosomal adaptor, MAPK and MTOR activator 5	3
<a href="#">23365</a>	ARHGEF12	Rho guanine nucleotide exchange factor 12	3
<a href="#">56947</a>	MFF	mitochondrial fission factor	3
<a href="#">84233</a>	TMEM126A	transmembrane protein 126A	3
<a href="#">3422</a>	IDI1	isopentenyl-diphosphate delta isomerase 1	3
<a href="#">81502</a>	HM13	histocompatibility minor 13	3
<a href="#">27339</a>	PRPF19	pre-mRNA processing factor 19	3
<a href="#">9875</a>	URB1	URB1 ribosome biogenesis 1 homolog (S. cerevisiae)	3
<a href="#">8454</a>	CUL1	cullin 1	3
<a href="#">51232</a>	CRIM1	cysteine rich transmembrane BMP regulator 1	3
<a href="#">9675</a>	TTI1	TELO2 interacting protein 1	3
<a href="#">9373</a>	PLAA	phospholipase A2 activating protein	3
<a href="#">4849</a>	CNOT3	CCR4-NOT transcription complex subunit 3	3
<a href="#">9261</a>	MAPKAPK2	mitogen-activated protein kinase-activated protein kinase 2	3
<a href="#">2926</a>	GRSF1	G-rich RNA sequence binding factor 1	3
<a href="#">54931</a>	TRMT10C	tRNA methyltransferase 10C, mitochondrial RNase P subunit	3
<a href="#">140465</a>	MYL6B	myosin light chain 6B	3
<a href="#">64374</a>	SIL1	SIL1 nucleotide exchange factor	3
<a href="#">51388</a>	NIP7	NIP7, nucleolar pre-rRNA processing protein	3
<a href="#">2037</a>	EPB41L2	erythrocyte membrane protein band 4.1 like 2	3
<a href="#">2146</a>	EZH2	enhancer of zeste 2 polycomb repressive complex 2 subunit	3
<a href="#">1503</a>	CTPS1	CTP synthase 1	3
<a href="#">51056</a>	LAP3	leucine aminopeptidase 3	3
<a href="#">64422</a>	ATG3	autophagy related 3	3
<a href="#">64425</a>	POLR1E	RNA polymerase I subunit E	3
<a href="#">5876</a>	RABGGTB	Rab geranylgeranyltransferase beta subunit	3
<a href="#">27340</a>	UTP20	UTP20, small subunit processome component	3
<a href="#">79954</a>	NOL10	nucleolar protein 10	3

<a href="#">10885</a>	WDR3	WD repeat domain 3	3
<a href="#">467</a>	ATF3	activating transcription factor 3	3
<a href="#">10775</a>	POP4	POP4 homolog, ribonuclease P/MRP subunit	3
<a href="#">27166</a>	PRELID1	PRELI domain containing 1	3
<a href="#">56945</a>	MRPS22	mitochondrial ribosomal protein S22	3
<a href="#">821</a>	CANX	calnexin	3
<a href="#">10525</a>	HYOU1	hypoxia up-regulated 1	3
<a href="#">7037</a>	TFRC	transferrin receptor	3
<a href="#">56005</a>	MYDGF	myeloid derived growth factor	3
<a href="#">9879</a>	DDX46	DEAD-box helicase 46	3
<a href="#">55131</a>	RBM28	RNA binding motif protein 28	3
<a href="#">55920</a>	RCC2	regulator of chromosome condensation 2	3
<a href="#">3954</a>	LETM1	leucine zipper and EF-hand containing transmembrane protein 1	3
<a href="#">23603</a>	CORO1C	coronin 1C	3
<a href="#">54948</a>	MRPL16	mitochondrial ribosomal protein L16	3
<a href="#">22894</a>	DIS3	DIS3 homolog, exosome endoribonuclease and 3'-5' exoribonuclease	3
<a href="#">51249</a>	TMEM69	transmembrane protein 69	3
<a href="#">7873</a>	MANF	mesencephalic astrocyte derived neurotrophic factor	3
<a href="#">5393</a>	EXOSC9	exosome component 9	3
<a href="#">23197</a>	FAF2	Fas associated factor family member 2	3
<a href="#">5888</a>	RAD51	RAD51 recombinase	3
<a href="#">23761</a>	PISD	phosphatidylserine decarboxylase	3
<a href="#">125061</a>	AFMID	arylformamidase	3
<a href="#">5019</a>	OXCT1	3-oxoacid CoA-transferase 1	3
<a href="#">53371</a>	NUP54	nucleoporin 54	3
<a href="#">23404</a>	EXOSC2	exosome component 2	3
<a href="#">8208</a>	CHAF1B	chromatin assembly factor 1 subunit B	3
<a href="#">6240</a>	RRM1	ribonucleotide reductase catalytic subunit M1	3
<a href="#">78995</a>	C17orf53	chromosome 17 open reading frame 53	3
<a href="#">84930</a>	MASTL	microtubule associated serine/threonine kinase like	3
<a href="#">51514</a>	DTL	denticleless E3 ubiquitin protein ligase homolog	3
<a href="#">3837</a>	KPNB1	karyopherin subunit beta 1	3
<a href="#">9156</a>	EXO1	exonuclease 1	3
<a href="#">51194</a>	IPO11	importin 11	3
<a href="#">10036</a>	CHAF1A	chromatin assembly factor 1 subunit A	3
<a href="#">160897</a>	GPR180	G protein-coupled receptor 180	3
<a href="#">8243</a>	SMC1A	structural maintenance of chromosomes 1A	3
<a href="#">1122</a>	CHML	CHM like, Rab escort protein 2	3
<a href="#">22984</a>	PDCD11	programmed cell death 11	3
<a href="#">488</a>	ATP2A2	ATPase sarcoplasmic/endoplasmic reticulum Ca <sup>2+</sup> transporting 2	3
<a href="#">1874</a>	E2F4	E2F transcription factor 4	3
<a href="#">55746</a>	NUP133	nucleoporin 133	3
<a href="#">55973</a>	BCAP29	B-cell receptor associated protein 29	3
<a href="#">84271</a>	POLDIP3	DNA polymerase delta interacting protein 3	3
<a href="#">55127</a>	HEATR1	HEAT repeat containing 1	3
<a href="#">128869</a>	PIGU	phosphatidylinositol glycan anchor biosynthesis class U	3
<a href="#">79053</a>	ALG8	ALG8, alpha-1,3-glucosyltransferase	3
<a href="#">2956</a>	MSH6	mutS homolog 6	3
<a href="#">57678</a>	GPAM	glycerol-3-phosphate acyltransferase, mitochondrial	3
<a href="#">9401</a>	RECQL4	RecQ like helicase 4	3
<a href="#">79796</a>	ALG9	ALG9, alpha-1,2-mannosyltransferase	3
<a href="#">993</a>	CDC25A	cell division cycle 25A	3
<a href="#">56926</a>	NCLN	nicalin	3
<a href="#">9816</a>	URB2	URB2 ribosome biogenesis 2 homolog (S. cerevisiae)	3
<a href="#">10560</a>	SLC19A2	solute carrier family 19 member 2	3
<a href="#">80223</a>	RAB11FIP1	RAB11 family interacting protein 1	3
<a href="#">9733</a>	SART3	squamous cell carcinoma antigen recognized by T-cells 3	3
<a href="#">22934</a>	RPIA	ribose 5-phosphate isomerase A	3
<a href="#">10531</a>	PITRM1	pitrilysin metalloproteinase 1	3
<a href="#">3251</a>	HPRT1	hypoxanthine phosphoribosyltransferase 1	3
<a href="#">8833</a>	GMPS	guanine monophosphate synthase	3
<a href="#">2175</a>	FANCA	Fanconi anemia complementation group A	3
<a href="#">25788</a>	RAD54B	RAD54 homolog B (S. cerevisiae)	3
<a href="#">80155</a>	NAA15	N(alpha)-acetyltransferase 15, NatA auxiliary subunit	3
<a href="#">79723</a>	SUV39H2	suppressor of variegation 3-9 homolog 2	3
<a href="#">132789</a>	GNPDA2	glucosamine-6-phosphate deaminase 2	3

<a href="#">23234</a>	DNAJC9	DnaJ heat shock protein family (Hsp40) member C9	3
<a href="#">57510</a>	XPO5	exportin 5	3
<a href="#">6119</a>	RPA3	replication protein A3	3
<a href="#">39</a>	ACAT2	acetyl-CoA acetyltransferase 2	3
<a href="#">7993</a>	UBXN8	UBX domain protein 8	3
<a href="#">10105</a>	PPIF	peptidylprolyl isomerase F	3
<a href="#">57003</a>	CCDC47	coiled-coil domain containing 47	3
<a href="#">57415</a>	C3orf14	chromosome 3 open reading frame 14	3
<a href="#">10652</a>	YKT6	YKT6 v-SNARE homolog (S. cerevisiae)	3
<a href="#">7374</a>	UNG	uracil DNA glycosylase	3
<a href="#">51602</a>	NOP58	NOP58 ribonucleoprotein	3
<a href="#">6566</a>	SLC16A1	solute carrier family 16 member 1	3
<a href="#">4173</a>	MCM4	minichromosome maintenance complex component 4	3
<a href="#">894</a>	CCND2	cyclin D2	3
<a href="#">9790</a>	BMS1	BMS1, ribosome biogenesis factor	3
<a href="#">51118</a>	UTP11	UTP11, small subunit processome component homolog (S. cerevisiae)	3
<a href="#">51126</a>	NAA20	N(alpha)-acetyltransferase 20, NatB catalytic subunit	3
<a href="#">10950</a>	BTG3	BTG anti-proliferation factor 3	3
<a href="#">10574</a>	CCT7	chaperonin containing TCP1 subunit 7	3
<a href="#">55646</a>	LYAR	Ly1 antibody reactive	3
<a href="#">84319</a>	CMSS1	cms1 ribosomal small subunit homolog (yeast)	3
<a href="#">120425</a>	JAML	junction adhesion molecule like	3
<a href="#">10471</a>	PFDN6	prefoldin subunit 6	3
<a href="#">51497</a>	NELFCD	negative elongation factor complex member C/D	3
<a href="#">131076</a>	CCDC58	coiled-coil domain containing 58	3
<a href="#">2067</a>	ERCC1	ERCC excision repair 1, endonuclease non-catalytic subunit	3
<a href="#">55299</a>	BRX1	BRX1, biogenesis of ribosomes	3
<a href="#">8520</a>	HAT1	histone acetyltransferase 1	3
<a href="#">1845</a>	DUSP3	dual specificity phosphatase 3	3
<a href="#">2321</a>	FLT1	fms related tyrosine kinase 1	3
<a href="#">5422</a>	POLA1	DNA polymerase alpha 1, catalytic subunit	3
<a href="#">55759</a>	WDR12	WD repeat domain 12	3
<a href="#">26010</a>	SPATS2L	spermatogenesis associated serine rich 2 like	3
<a href="#">5887</a>	RAD23B	RAD23 homolog B, nucleotide excision repair protein	3
<a href="#">23516</a>	SLC39A14	solute carrier family 39 member 14	3
<a href="#">83743</a>	GRWD1	glutamate rich WD repeat containing 1	3
<a href="#">5702</a>	PSMC3	proteasome 26S subunit, ATPase 3	3
<a href="#">54487</a>	DGCR8	DGCR8, microprocessor complex subunit	3
<a href="#">55720</a>	TSR1	TSR1, ribosome maturation factor	3
<a href="#">2547</a>	XRCC6	X-ray repair cross complementing 6	3
<a href="#">5982</a>	RFC2	replication factor C subunit 2	3
<a href="#">27346</a>	TMEM97	transmembrane protein 97	3
<a href="#">80179</a>	MYO19	myosin XIX	3
<a href="#">9343</a>	EFTUD2	elongation factor Tu GTP binding domain containing 2	3
<a href="#">220042</a>	DDIAS	DNA damage induced apoptosis suppressor	3
<a href="#">8318</a>	CDC45	cell division cycle 45	3
<a href="#">5471</a>	PPAT	phosphoribosyl pyrophosphate amidotransferase	3
<a href="#">990</a>	CDC6	cell division cycle 6	3
<a href="#">90861</a>	HN1L	hematological and neurological expressed 1 like	3
<a href="#">29128</a>	UHRF1	ubiquitin like with PHD and ring finger domains 1	3
<a href="#">1111</a>	CHEK1	checkpoint kinase 1	3
<a href="#">55854</a>	ZC3H15	zinc finger CCCH-type containing 15	3
<a href="#">4998</a>	ORC1	origin recognition complex subunit 1	3
<a href="#">5111</a>	PCNA	proliferating cell nuclear antigen	3
<a href="#">54962</a>	TIPIN	TIMELESS interacting protein	3
<a href="#">51377</a>	UCHL5	ubiquitin C-terminal hydrolase L5	3
<a href="#">9125</a>	CNOT9	CCR4-NOT transcription complex subunit 9	3
<a href="#">11222</a>	MRPL3	mitochondrial ribosomal protein L3	3
<a href="#">1965</a>	EIF2S1	eukaryotic translation initiation factor 2 subunit alpha	3
<a href="#">6427</a>	SRSF2	serine and arginine rich splicing factor 2	3
<a href="#">10623</a>	POLR3C	RNA polymerase III subunit C	3
<a href="#">7884</a>	SLBP	stem-loop binding protein	3
<a href="#">79622</a>	SNRNP25	small nuclear ribonucleoprotein U11/U12 subunit 25	3
<a href="#">4172</a>	MCM3	minichromosome maintenance complex component 3	3
<a href="#">2237</a>	FEN1	flap structure-specific endonuclease 1	3

<a href="#">171568</a>	POLR3H	RNA polymerase III subunit H	3
<a href="#">8704</a>	B4GALT2	beta-1,4-galactosyltransferase 2	3
<a href="#">55388</a>	MCM10	minichromosome maintenance 10 replication initiation factor	3
<a href="#">26509</a>	MYOF	myoferlin	3
<a href="#">94097</a>	SFXN5	sideroflexin 5	3
<a href="#">55379</a>	LRRC59	leucine rich repeat containing 59	3
<a href="#">2271</a>	FH	fumarate hydratase	3
<a href="#">26284</a>	ERAL1	Era like 12S mitochondrial rRNA chaperone 1	3
<a href="#">2958</a>	GTF2A2	general transcription factor IIA subunit 2	3
<a href="#">1869</a>	E2F1	E2F transcription factor 1	3
<a href="#">11332</a>	ACOT7	acyl-CoA thioesterase 7	3
<a href="#">898</a>	CCNE1	cyclin E1	3
<a href="#">5983</a>	RFC3	replication factor C subunit 3	3
<a href="#">3021</a>	H3F3B	H3 histone family member 3B	3
<a href="#">10419</a>	PRMT5	protein arginine methyltransferase 5	3
<a href="#">64858</a>	DCLRE1B	DNA cross-link repair 1B	3
<a href="#">10054</a>	UBA2	ubiquitin like modifier activating enzyme 2	3
<a href="#">2176</a>	FANCC	Fanconi anemia complementation group C	3
<a href="#">51124</a>	IER3IP1	immediate early response 3 interacting protein 1	3
<a href="#">126526</a>	C19orf47	chromosome 19 open reading frame 47	3
<a href="#">60386</a>	SLC25A19	solute carrier family 25 member 19	3
<a href="#">56910</a>	STAR7	StAR related lipid transfer domain containing 7	3
<a href="#">3976</a>	LIF	leukemia inhibitory factor	3
<a href="#">1841</a>	DTYMK	deoxythymidylate kinase	3
<a href="#">10556</a>	RPP30	ribonuclease P/MRP subunit p30	3
<a href="#">10360</a>	NPM3	nucleophosmin/nucleoplasmin 3	3
<a href="#">114034</a>	TOE1	target of EGR1, member 1 (nuclear)	3
<a href="#">79693</a>	YRDC	yrDC N6-threonylcarbamoyltransferase domain containing	3
<a href="#">5631</a>	PRPS1	phosphoribosyl pyrophosphate synthetase 1	3
<a href="#">56851</a>	EMC7	ER membrane protein complex subunit 7	3
<a href="#">10949</a>	HNRNPA0	heterogeneous nuclear ribonucleoprotein A0	3
<a href="#">51559</a>	NT5DC3	5'-nucleotidase domain containing 3	3
<a href="#">79682</a>	CENPU	centromere protein U	3
<a href="#">9410</a>	SNRNP40	small nuclear ribonucleoprotein U5 subunit 40	3
<a href="#">8624</a>	PSMG1	proteasome assembly chaperone 1	3
<a href="#">5557</a>	PRIM1	primase (DNA) subunit 1	3
<a href="#">55159</a>	RFWD3	ring finger and WD repeat domain 3	3
<a href="#">29089</a>	UBE2T	ubiquitin conjugating enzyme E2 T	3
<a href="#">84515</a>	MCM8	minichromosome maintenance 8 homologous recombination repair factor	3
<a href="#">11164</a>	NUDT5	nudix hydrolase 5	3
<a href="#">203068</a>	TUBB	tubulin beta class I	3
<a href="#">6472</a>	SHMT2	serine hydroxymethyltransferase 2	3
<a href="#">132</a>	ADK	adenosine kinase	3
<a href="#">401541</a>	CENPP	centromere protein P	3
<a href="#">805</a>	CALM2	calmodulin 2	3
<a href="#">4616</a>	GADD45B	growth arrest and DNA damage inducible beta	3
<a href="#">10328</a>	EMC8	ER membrane protein complex subunit 8	3
<a href="#">5546</a>	PRCC	papillary renal cell carcinoma (translocation-associated)	3
<a href="#">1164</a>	CKS2	CDC28 protein kinase regulatory subunit 2	3
<a href="#">27242</a>	TNFRSF21	TNF receptor superfamily member 21	3
<a href="#">9318</a>	COPS2	COP9 signalosome subunit 2	3
<a href="#">56993</a>	TOMM22	translocase of outer mitochondrial membrane 22	3
<a href="#">84549</a>	MAK16	MAK16 homolog	3
<a href="#">5437</a>	POLR2H	RNA polymerase II subunit H	3
<a href="#">388272</a>	C16orf87	chromosome 16 open reading frame 87	3
<a href="#">113115</a>	MTFR2	mitochondrial fission regulator 2	3
<a href="#">4043</a>	LRPAP1	LDL receptor related protein associated protein 1	3
<a href="#">55347</a>	ABHD10	abhydrolase domain containing 10	3
<a href="#">79968</a>	WDR76	WD repeat domain 76	3
<a href="#">262</a>	AMD1	adenosylmethionine decarboxylase 1	3
<a href="#">27131</a>	SNX5	sorting nexin 5	3
<a href="#">93081</a>	TEX30	testis expressed 30	3
<a href="#">200081</a>	TXLNA	taxilin alpha	3
<a href="#">84334</a>	APOPT1	apoptogenic 1, mitochondrial	3
<a href="#">8836</a>	GGH	gamma-glutamyl hydrolase	3

<a href="#">1528</a>	CYB5A	cytochrome b5 type A	3
<a href="#">122769</a>	LRR1	leucine rich repeat protein 1	3
<a href="#">8896</a>	BUD31	BUD31 homolog	3
<a href="#">7922</a>	SLC39A7	solute carrier family 39 member 7	3
<a href="#">83903</a>	GSG2	germ cell associated 2, haspin	3
<a href="#">79019</a>	CENPM	centromere protein M	3
<a href="#">10038</a>	PARP2	poly(ADP-ribose) polymerase 2	3
<a href="#">11130</a>	ZWINT	ZW10 interacting kinetochore protein	3
<a href="#">91</a>	ACVR1B	activin A receptor type 1B	3
<a href="#">6742</a>	SSBP1	single stranded DNA binding protein 1	3
<a href="#">7398</a>	USP1	ubiquitin specific peptidase 1	3
<a href="#">79980</a>	DSN1	DSN1 homolog, MIS12 kinetochore complex component	3
<a href="#">9134</a>	CCNE2	cyclin E2	3
<a href="#">387103</a>	CENPW	centromere protein W	3
<a href="#">9984</a>	THOC1	THO complex 1	3
<a href="#">23421</a>	ITGB3BP	integrin subunit beta 3 binding protein	3
<a href="#">54108</a>	CHRAC1	chromatin accessibility complex 1	3
<a href="#">79801</a>	SHCBP1	SHC binding and spindle associated 1	3
<a href="#">3185</a>	HNRNPF	heterogeneous nuclear ribonucleoprotein F	3
<a href="#">813</a>	CALU	calumenin	3
<a href="#">10733</a>	PLK4	polo like kinase 4	3
<a href="#">211</a>	ALAS1	5'-aminolevulinatase synthase 1	3
<a href="#">81831</a>	NETO2	neuropilin and tolloid like 2	3
<a href="#">79001</a>	VKORC1	vitamin K epoxide reductase complex subunit 1	3
<a href="#">26123</a>	TCTN3	tectonic family member 3	3
<a href="#">25896</a>	INTS7	integrator complex subunit 7	3
<a href="#">64834</a>	ELOVL1	ELOVL fatty acid elongase 1	3
<a href="#">80304</a>	WDPC	WD repeat and coiled coil containing	3
<a href="#">51550</a>	CINP	cyclin dependent kinase 2 interacting protein	3
<a href="#">38</a>	ACAT1	acetyl-CoA acetyltransferase 1	3
<a href="#">79084</a>	WDR77	WD repeat domain 77	3
<a href="#">219988</a>	PATL1	PAT1 homolog 1, processing body mRNA decay factor	3
<a href="#">63979</a>	FIGNL1	figetin like 1	3
<a href="#">10772</a>	SRSF10	serine and arginine rich splicing factor 10	3
<a href="#">6788</a>	STK3	serine/threonine kinase 3	3
<a href="#">85459</a>	CEP295	centrosomal protein 295	3
<a href="#">2746</a>	GLUD1	glutamate dehydrogenase 1	3
<a href="#">58490</a>	RPRD1B	regulation of nuclear pre-mRNA domain containing 1B	3
<a href="#">3005</a>	H1FO	H1 histone family member 0	3
<a href="#">55163</a>	PNPO	pyridoxamine 5'-phosphate oxidase	3
<a href="#">114134</a>	SLC2A13	solute carrier family 2 member 13	3
<a href="#">7384</a>	UQCRC1	ubiquinol-cytochrome c reductase core protein I	3
<a href="#">23509</a>	POFUT1	protein O-fucosyltransferase 1	3
<a href="#">975</a>	CD81	CD81 molecule	3
<a href="#">7408</a>	VASP	vasodilator-stimulated phosphoprotein	3
<a href="#">93323</a>	HAUS8	HAUS augmin like complex subunit 8	3
<a href="#">124535</a>	HSF5	heat shock transcription factor 5	3
<a href="#">85444</a>	LRRCC1	leucine rich repeat and coiled-coil centrosomal protein 1	3
<a href="#">51150</a>	SDF4	stromal cell derived factor 4	3
<a href="#">56919</a>	DHX33	DEAH-box helicase 33	3
<a href="#">23035</a>	PHLPP2	PH domain and leucine rich repeat protein phosphatase 2	3
<a href="#">8879</a>	SGPL1	sphingosine-1-phosphate lyase 1	3
<a href="#">51593</a>	SRRT	serrate, RNA effector molecule	3
<a href="#">790</a>	CAD	carbamoyl-phosphate synthetase 2, aspartate transcarbamylase, and dihydroorotase	3
<a href="#">6541</a>	SLC7A1	solute carrier family 7 member 1	3
<a href="#">6835</a>	SURF2	surfeit 2	3
<a href="#">84306</a>	PDCD2L	programmed cell death 2 like	3
<a href="#">51693</a>	TRAPPC2L	trafficking protein particle complex 2 like	3
<a href="#">7001</a>	PRDX2	peroxiredoxin 2	3
<a href="#">22976</a>	PAXIP1	PAX interacting protein 1	3
<a href="#">51692</a>	CPSF3	cleavage and polyadenylation specific factor 3	3
<a href="#">11193</a>	WBP4	WW domain binding protein 4	3
<a href="#">6827</a>	SUPT4H1	SPT4 homolog, DSIF elongation factor subunit	3
<a href="#">116224</a>	FAM122A	family with sequence similarity 122A	3

<a href="#">51110</a>	LACTB2	lactamase beta 2	3
<a href="#">29063</a>	ZCCHC4	zinc finger CCHC-type containing 4	3
<a href="#">57552</a>	NCEH1	neutral cholesterol ester hydrolase 1	3
<a href="#">60528</a>	ELAC2	elaC ribonuclease Z 2	3
<a href="#">79174</a>	CRELD2	cysteine rich with EGF like domains 2	3
<a href="#">83940</a>	TATDN1	TatD DNase domain containing 1	3
<a href="#">117246</a>	FTSJ3	FtsJ homolog 3	3
<a href="#">390916</a>	NUDT19	nudix hydrolase 19	3
<a href="#">1478</a>	CSTF2	cleavage stimulation factor subunit 2	3
<a href="#">1017</a>	CDK2	cyclin dependent kinase 2	3
<a href="#">221830</a>	TWISTNB	TWIST neighbor	3
<a href="#">10383</a>	TUBB4B	tubulin beta 4B class IVb	3
<a href="#">65003</a>	MRPL11	mitochondrial ribosomal protein L11	3
<a href="#">5366</a>	PMAIP1	phorbol-12-myristate-13-acetate-induced protein 1	3
<a href="#">54939</a>	COMMMD4	COMM domain containing 4	3
<a href="#">56912</a>	IFT46	intraflagellar transport 46	3
<a href="#">51258</a>	MRPL51	mitochondrial ribosomal protein L51	3
<a href="#">6478</a>	SIAH2	siah E3 ubiquitin protein ligase 2	3
<a href="#">29093</a>	MRPL22	mitochondrial ribosomal protein L22	3
<a href="#">79073</a>	TMEM109	transmembrane protein 109	3
<a href="#">92745</a>	SLC38A5	solute carrier family 38 member 5	3
<a href="#">9183</a>	ZW10	zw10 kinetochore protein	3
<a href="#">6390</a>	SDHB	succinate dehydrogenase complex iron sulfur subunit B	3
<a href="#">64223</a>	MLST8	MTOR associated protein, LST8 homolog	3
<a href="#">55915</a>	LANCL2	LanC like 2	3
<a href="#">57095</a>	PITHD1	PITH domain containing 1	3
<a href="#">7917</a>	BAG6	BCL2 associated athanogene 6	3
<a href="#">1603</a>	DAD1	defender against cell death 1	3
<a href="#">533</a>	ATP6V0B	ATPase H+ transporting V0 subunit b	3
<a href="#">130355</a>	C2orf76	chromosome 2 open reading frame 76	3
<a href="#">9040</a>	UBE2M	ubiquitin conjugating enzyme E2 M	3
<a href="#">5708</a>	PSMD2	proteasome 26S subunit, non-ATPase 2	3
<a href="#">253714</a>	MMS22L	MMS22 like, DNA repair protein	3
<a href="#">5685</a>	PSMA4	proteasome subunit alpha 4	3
<a href="#">5203</a>	PFDN4	prefoldin subunit 4	3
<a href="#">1376</a>	CPT2	carnitine palmitoyltransferase 2	3
<a href="#">27229</a>	TUBGCP4	tubulin gamma complex associated protein 4	3
<a href="#">83746</a>	L3MBTL2	L3MBTL2 polycomb repressive complex 1 subunit	3
<a href="#">334</a>	APLP2	amyloid beta precursor like protein 2	3
<a href="#">1737</a>	DLAT	dihydrolipoamide S-acetyltransferase	3
<a href="#">5034</a>	P4HB	prolyl 4-hydroxylase subunit beta	3
<a href="#">51053</a>	GMNN	geminin, DNA replication inhibitor	3
<a href="#">51728</a>	POLR3K	RNA polymerase III subunit K	3
<a href="#">116138</a>	KLHDC3	kelch domain containing 3	3
<a href="#">27249</a>	MMADHC	methylmalonic aciduria and homocystinuria, cbID type	3
<a href="#">57019</a>	CIAPIN1	cytokine induced apoptosis inhibitor 1	3
<a href="#">81037</a>	CLPTM1L	CLPTM1 like	3
<a href="#">9862</a>	MED24	mediator complex subunit 24	3
<a href="#">580</a>	BARD1	BRCA1 associated RING domain 1	3
<a href="#">9703</a>	KIAA0100	KIAA0100	3
<a href="#">9538</a>	EI24	EI24, autophagy associated transmembrane protein	3
<a href="#">28957</a>	MRPS28	mitochondrial ribosomal protein S28	3
<a href="#">23534</a>	TNPO3	transportin 3	3
<a href="#">54471</a>	MIEF1	mitochondrial elongation factor 1	3
<a href="#">51264</a>	MRPL27	mitochondrial ribosomal protein L27	3
<a href="#">689</a>	BTF3	basic transcription factor 3	3
<a href="#">7982</a>	ST7	suppression of tumorigenicity 7	3
<a href="#">5984</a>	RFC4	replication factor C subunit 4	3
<a href="#">81875</a>	ISG20L2	interferon stimulated exonuclease gene 20 like 2	3
<a href="#">80010</a>	RMI1	RecQ mediated genome instability 1	3
<a href="#">127253</a>	TYW3	tRNA-yW synthesizing protein 3 homolog	3
<a href="#">8607</a>	RUVBL1	RuvB like AAA ATPase 1	3
<a href="#">10971</a>	YWHAQ	tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein theta	3
<a href="#">51253</a>	MRPL37	mitochondrial ribosomal protein L37	3

<a href="#">740</a>	MRPL49	mitochondrial ribosomal protein L49	3
<a href="#">92399</a>	MRRF	mitochondrial ribosome recycling factor	3
<a href="#">6941</a>	TCF19	transcription factor 19	3
<a href="#">4176</a>	MCM7	minichromosome maintenance complex component 7	3
<a href="#">79751</a>	SLC25A22	solute carrier family 25 member 22	3
<a href="#">129401</a>	NUP35	nucleoporin 35	3
<a href="#">4085</a>	MAD2L1	MAD2 mitotic arrest deficient-like 1 (yeast)	3
<a href="#">79892</a>	MCMBP	minichromosome maintenance complex binding protein	3
<a href="#">7705</a>	ZNF146	zinc finger protein 146	3
<a href="#">10857</a>	PGRMC1	progesterone receptor membrane component 1	3
<a href="#">140707</a>	BRI3BP	BRI3 binding protein	3
<a href="#">84798</a>	C19orf48	chromosome 19 open reading frame 48	3
<a href="#">4733</a>	DRG1	developmentally regulated GTP binding protein 1	3
<a href="#">3458</a>	IFNG	interferon gamma	3
<a href="#">7124</a>	TNF	tumor necrosis factor	3
<a href="#">60678</a>	EEFSEC	eukaryotic elongation factor, selenocysteine-tRNA specific	3
<a href="#">55706</a>	NDC1	NDC1 transmembrane nucleoporin	3
<a href="#">56006</a>	SMG9	SMG9, nonsense mediated mRNA decay factor	3
<a href="#">1437</a>	CSF2	colony stimulating factor 2	3
<a href="#">9093</a>	DNAJA3	DnaJ heat shock protein family (Hsp40) member A3	3
<a href="#">55536</a>	CDCA7L	cell division cycle associated 7 like	3
<a href="#">23594</a>	ORC6	origin recognition complex subunit 6	3
<a href="#">81611</a>	ANP32E	acidic nuclear phosphoprotein 32 family member E	3
<a href="#">55166</a>	CENPQ	centromere protein Q	3
<a href="#">90121</a>	TSR2	TSR2, ribosome maturation factor	3
<a href="#">64795</a>	RMND5A	required for meiotic nuclear division 5 homolog A	3
<a href="#">2187</a>	FANCB	Fanconi anemia complementation group B	3
<a href="#">3595</a>	IL12RB2	interleukin 12 receptor subunit beta 2	3
<a href="#">2747</a>	GLUD2	glutamate dehydrogenase 2	3
<a href="#">57001</a>	SDHAF3	succinate dehydrogenase complex assembly factor 3	3
<a href="#">10714</a>	POLD3	DNA polymerase delta 3, accessory subunit	3
<a href="#">51522</a>	TMEM14C	transmembrane protein 14C	3
<a href="#">8841</a>	HDAC3	histone deacetylase 3	3
<a href="#">134145</a>	FAM173B	family with sequence similarity 173 member B	3
<a href="#">10527</a>	IPO7	importin 7	3
<a href="#">10768</a>	AHCYL1	adenosylhomocysteinase like 1	3
<a href="#">29851</a>	ICOS	inducible T-cell costimulator	3
<a href="#">5433</a>	POLR2D	RNA polymerase II subunit D	3
<a href="#">9533</a>	POLR1C	RNA polymerase I subunit C	3
<a href="#">54675</a>	CRLS1	cardiolipin synthase 1	3
<a href="#">145173</a>	B3GLCT	beta 3-glucosyltransferase	3
<a href="#">57602</a>	USP36	ubiquitin specific peptidase 36	3
<a href="#">9801</a>	MRPL19	mitochondrial ribosomal protein L19	3
<a href="#">10539</a>	GLRX3	glutaredoxin 3	3
<a href="#">10921</a>	RNPS1	RNA binding protein with serine rich domain 1	3
<a href="#">92856</a>	IMP4	IMP4 homolog, U3 small nucleolar ribonucleoprotein	3
<a href="#">5810</a>	RAD1	RAD1 checkpoint DNA exonuclease methylenetetrahydrofolate dehydrogenase (NADP+ dependent) 2,	3
<a href="#">10797</a>	MTHFD2	methylenetetrahydrofolate cyclohydrolase	3
<a href="#">55735</a>	DNAJC11	DnaJ heat shock protein family (Hsp40) member C11	3
<a href="#">10713</a>	USP39	ubiquitin specific peptidase 39	3
<a href="#">81929</a>	SEH1L	SEH1 like nucleoporin	3
<a href="#">5717</a>	PSMD11	proteasome 26S subunit, non-ATPase 11	3
<a href="#">5917</a>	RARS	arginyl-tRNA synthetase	3
<a href="#">27258</a>	LSM3	LSM3 homolog, U6 small nuclear RNA and mRNA degradation associated	3
<a href="#">51182</a>	HSPA14	heat shock protein family A (Hsp70) member 14	3
<a href="#">6950</a>	TCP1	t-complex 1	3
<a href="#">5860</a>	QDPR	quinoid dihydropteridine reductase	3
<a href="#">8079</a>	MLF2	myeloid leukemia factor 2	3
<a href="#">51645</a>	PPIL1	peptidylprolyl isomerase like 1	3
<a href="#">5985</a>	RFC5	replication factor C subunit 5	3
<a href="#">3843</a>	IPO5	importin 5	3
<a href="#">22936</a>	ELL2	elongation factor for RNA polymerase II 2	3
<a href="#">10166</a>	SLC25A15	solute carrier family 25 member 15	3
<a href="#">55622</a>	TTC27	tetratricopeptide repeat domain 27	3

<a href="#">51002</a>	TPRKB	TP53RK binding protein	3
<a href="#">23392</a>	KIAA0368	KIAA0368	3
<a href="#">53407</a>	STX18	syntaxin 18	3
<a href="#">10059</a>	DNM1L	dynamamin 1 like	3
<a href="#">9774</a>	BCLAF1	BCL2 associated transcription factor 1	3
<a href="#">84641</a>	MFSD14B	major facilitator superfamily domain containing 14B	3
<a href="#">8677</a>	STX10	syntaxin 10	3
<a href="#">81873</a>	ARPC5L	actin related protein 2/3 complex subunit 5 like	3
<a href="#">51575</a>	ESF1	ESF1 nucleolar pre-rRNA processing protein homolog	3
<a href="#">988</a>	CDC5L	cell division cycle 5 like	3
<a href="#">2957</a>	GTF2A1	general transcription factor IIA subunit 1	3
<a href="#">23597</a>	ACOT9	acyl-CoA thioesterase 9	3
<a href="#">81554</a>	RCC1L	RCC1 like	3
<a href="#">3654</a>	IRAK1	interleukin 1 receptor associated kinase 1	3
<a href="#">55149</a>	MTPAP	mitochondrial poly(A) polymerase	3
<a href="#">80775</a>	TMEM177	transmembrane protein 177	3
<a href="#">64216</a>	TFB2M	transcription factor B2, mitochondrial	3
<a href="#">10592</a>	SMC2	structural maintenance of chromosomes 2	3
<a href="#">140735</a>	DYNLL2	dynein light chain LC8-type 2	3
<a href="#">47</a>	ACLY	ATP citrate lyase	3
<a href="#">5832</a>	ALDH18A1	aldehyde dehydrogenase 18 family member A1	3
<a href="#">1138</a>	CHRNA5	cholinergic receptor nicotinic alpha 5 subunit	3
<a href="#">125228</a>	FAM210A	family with sequence similarity 210 member A	3
<a href="#">23649</a>	POLA2	DNA polymerase alpha 2, accessory subunit	3
<a href="#">55627</a>	SMPD4	sphingomyelin phosphodiesterase 4	3
<a href="#">6510</a>	SLC1A5	solute carrier family 1 member 5	3
<a href="#">58478</a>	ENOPH1	enolase-phosphatase 1	3
<a href="#">2806</a>	GOT2	glutamic-oxaloacetic transaminase 2	3
<a href="#">5534</a>	PPP3R1	protein phosphatase 3 regulatory subunit B, alpha	3
<a href="#">88745</a>	RRP36	ribosomal RNA processing 36	3
<a href="#">79863</a>	RBFA	ribosome binding factor A (putative)	3
<a href="#">10884</a>	MRPS30	mitochondrial ribosomal protein S30	3
<a href="#">9015</a>	TAF1A	TATA-box binding protein associated factor, RNA polymerase I subunit A	3
<a href="#">79029</a>	SPATA5L1	spermatogenesis associated 5 like 1	3
<a href="#">80311</a>	KLHL15	kelch like family member 15	3
<a href="#">64946</a>	CENPH	centromere protein H	3
<a href="#">8438</a>	RAD54L	RAD54-like (S. cerevisiae)	3
<a href="#">7298</a>	TYMS	thymidylate synthetase	3
<a href="#">9768</a>	KIAA0101	KIAA0101	3
<a href="#">6502</a>	SKP2	S-phase kinase associated protein 2	3
<a href="#">5427</a>	POLE2	DNA polymerase epsilon 2, accessory subunit	3
<a href="#">79902</a>	NUP85	nucleoporin 85	3
<a href="#">8723</a>	SNX4	sorting nexin 4	3
<a href="#">5932</a>	RBBP8	RB binding protein 8, endonuclease	3
<a href="#">3070</a>	HELLS	helicase, lymphoid-specific	3
<a href="#">672</a>	BRCA1	BRCA1, DNA repair associated	3
<a href="#">79075</a>	DSCC1	DNA replication and sister chromatid cohesion 1	3
<a href="#">7083</a>	TK1	thymidine kinase 1	3
<a href="#">91768</a>	CABLES1	Cdk5 and Abl enzyme substrate 1	3
<a href="#">10099</a>	TSPAN3	tetraspanin 3	3
<a href="#">130074</a>	FAM168B	family with sequence similarity 168 member B	3
<a href="#">79807</a>	GSTCD	glutathione S-transferase C-terminal domain containing	3
<a href="#">83480</a>	PUS3	pseudouridylate synthase 3	3
<a href="#">54442</a>	KCTD5	potassium channel tetramerization domain containing 5	3
<a href="#">55559</a>	HAUS7	HAUS augmin like complex subunit 7	3
<a href="#">79003</a>	MIS12	MIS12, kinetochore complex component	3
<a href="#">1763</a>	DNA2	DNA replication helicase/nuclease 2	3
<a href="#">9328</a>	GTF3C5	general transcription factor IIIC subunit 5	3
<a href="#">10552</a>	ARPC1A	actin related protein 2/3 complex subunit 1A	3
<a href="#">29925</a>	GMPPB	GDP-mannose pyrophosphorylase B	3
<a href="#">134353</a>	LSM11	LSM11, U7 small nuclear RNA associated	3
<a href="#">25914</a>	RTTN	rotatin	3
<a href="#">207</a>	AKT1	AKT serine/threonine kinase 1	3
<a href="#">64837</a>	KLC2	kinesin light chain 2	3

<a href="#">8131</a>	NPRL3	NPR3 like, GATOR1 complex subunit	3
<a href="#">116113</a>	FOXP4	forkhead box P4	3
<a href="#">55677</a>	IWS1	IWS1, SUPT6H interacting protein	3
<a href="#">10749</a>	KIF1C	kinesin family member 1C	3
<a href="#">9019</a>	MPZL1	myelin protein zero like 1	3
<a href="#">84885</a>	ZDHHC12	zinc finger DHHC-type containing 12	3
<a href="#">55509</a>	BATF3	basic leucine zipper ATF-like transcription factor 3	3
<a href="#">54976</a>	C20orf27	chromosome 20 open reading frame 27	3
<a href="#">56616</a>	DIABLO	diablo IAP-binding mitochondrial protein	3
<a href="#">10856</a>	RUVBL2	RuvB like AAA ATPase 2	3
<a href="#">55969</a>	C20orf24	chromosome 20 open reading frame 24	3
<a href="#">100506012</a>	PPP5D1	PPP5 tetratricopeptide repeat domain containing 1	3
<a href="#">57418</a>	WDR18	WD repeat domain 18	3
<a href="#">10572</a>	SIVA1	SIVA1 apoptosis inducing factor	3
<a href="#">9653</a>	HS2ST1	heparan sulfate 2-O-sulfotransferase 1	3
<a href="#">9031</a>	BAZ1B	bromodomain adjacent to zinc finger domain 1B	3
<a href="#">55922</a>	NKRF	NFKB repressing factor	3
<a href="#">10594</a>	PRPF8	pre-mRNA processing factor 8	3
<a href="#">2235</a>	FECH	ferrochelatase	3
<a href="#">54934</a>	KANSL2	KAT8 regulatory NSL complex subunit 2	3
<a href="#">339231</a>	ARL16	ADP ribosylation factor like GTPase 16	3
<a href="#">5514</a>	PPP1R10	protein phosphatase 1 regulatory subunit 10	3
<a href="#">4193</a>	MDM2	MDM2 proto-oncogene	3
<a href="#">126731</a>	CCSAP	centriole, cilia and spindle associated protein	3
<a href="#">387338</a>	NSUN4	NOP2/Sun RNA methyltransferase family member 4	3
<a href="#">64318</a>	NOC3L	NOC3 like DNA replication regulator	3
<a href="#">64083</a>	GOLPH3	golgi phosphoprotein 3	3
<a href="#">10478</a>	SLC25A17	solute carrier family 25 member 17	3
<a href="#">11157</a>	LSM6	LSM6 homolog, U6 small nuclear RNA and mRNA degradation associated	3
<a href="#">79989</a>	TTC26	tetratricopeptide repeat domain 26	3
<a href="#">56894</a>	AGPAT3	1-acylglycerol-3-phosphate O-acyltransferase 3	3
<a href="#">1983</a>	EIF5	eukaryotic translation initiation factor 5	3
<a href="#">56652</a>	C10orf2	chromosome 10 open reading frame 2	3
<a href="#">22891</a>	ZNF365	zinc finger protein 365	3
<a href="#">221035</a>	REEP3	receptor accessory protein 3	3
<a href="#">54707</a>	GPN2	GPN-loop GTPase 2	3
<a href="#">51022</a>	GLRX2	glutaredoxin 2	3
<a href="#">79066</a>	METTL16	methyltransferase like 16	3
<a href="#">57862</a>	ZNF410	zinc finger protein 410	3
<a href="#">9240</a>	PNMA1	paraneoplastic Ma antigen 1	3
<a href="#">51204</a>	TACO1	translational activator of cytochrome c oxidase I	3
<a href="#">7292</a>	TNFSF4	tumor necrosis factor superfamily member 4	3
<a href="#">79568</a>	C2orf47	chromosome 2 open reading frame 47	3
<a href="#">7584</a>	ZNF35	zinc finger protein 35	3
<a href="#">4709</a>	NDUFB3	NADH:ubiquinone oxidoreductase subunit B3	3
<a href="#">55572</a>	FOXRED1	FAD dependent oxidoreductase domain containing 1	3
<a href="#">56683</a>	C21orf59	chromosome 21 open reading frame 59	3
<a href="#">23423</a>	TMED3	transmembrane p24 trafficking protein 3	3
<a href="#">5134</a>	PDCD2	programmed cell death 2	3
<a href="#">84289</a>	ING5	inhibitor of growth family member 5	3
<a href="#">527</a>	ATP6V0C	ATPase H+ transporting V0 subunit c	3
<a href="#">1978</a>	EIF4EBP1	eukaryotic translation initiation factor 4E binding protein 1	3
<a href="#">6628</a>	SNRPB	small nuclear ribonucleoprotein polypeptides B and B1	3
<a href="#">1981</a>	EIF4G1	eukaryotic translation initiation factor 4 gamma 1	3
<a href="#">10221</a>	TRIB1	tribbles pseudokinase 1	3
<a href="#">157506</a>	RDH10	retinol dehydrogenase 10 (all-trans)	3
<a href="#">79413</a>	ZBED2	zinc finger BED-type containing 2	3
<a href="#">6182</a>	MRPL12	mitochondrial ribosomal protein L12	3
<a href="#">201514</a>	ZNF584	zinc finger protein 584	3
<a href="#">7023</a>	TFAP4	transcription factor AP-4	3
<a href="#">8228</a>	PNPLA4	patatin like phospholipase domain containing 4	3
<a href="#">2593</a>	GAMT	guanidinoacetate N-methyltransferase	3
<a href="#">9144</a>	SYNGR2	synaptogyrin 2	3
<a href="#">2876</a>	GPX1	glutathione peroxidase 1	3
<a href="#">29914</a>	UBIAD1	UbiA prenyltransferase domain containing 1	3

<a href="#">5050</a>	PFAFH1B3	platelet activating factor acetylhydrolase 1b catalytic subunit 3	3
<a href="#">23276</a>	KLHL18	kelch like family member 18	3
<a href="#">51647</a>	FAM96B	family with sequence similarity 96 member B	3
<a href="#">23381</a>	SMG5	SMG5, nonsense mediated mRNA decay factor	3
<a href="#">5714</a>	PSMD8	proteasome 26S subunit, non-ATPase 8	3
<a href="#">4946</a>	OAZ1	ornithine decarboxylase antizyme 1	3
<a href="#">6647</a>	SOD1	superoxide dismutase 1, soluble	3
<a href="#">4234</a>	METTL1	methyltransferase like 1	3
<a href="#">116238</a>	TLCD1	TLC domain containing 1	3
<a href="#">7167</a>	TPI1	triosephosphate isomerase 1	3
<a href="#">10953</a>	TOMM34	translocase of outer mitochondrial membrane 34	3
<a href="#">27341</a>	RRP7A	ribosomal RNA processing 7 homolog A	3
<a href="#">65057</a>	ACD	adrenocortical dysplasia homolog	3
<a href="#">64943</a>	NT5DC2	5'-nucleotidase domain containing 2	3
<a href="#">5425</a>	POLD2	DNA polymerase delta 2, accessory subunit	3
<a href="#">79143</a>	MBOAT7	membrane bound O-acyltransferase domain containing 7	3
<a href="#">9361</a>	LONP1	lon peptidase 1, mitochondrial	3
<a href="#">6150</a>	MRPL23	mitochondrial ribosomal protein L23	3
<a href="#">1337</a>	COX6A1	cytochrome c oxidase subunit 6A1	3
<a href="#">10726</a>	NUDC	nuclear distribution C, dynein complex regulator	3
<a href="#">51690</a>	LSM7	LSM7 homolog, U6 small nuclear RNA and mRNA degradation associated	3
<a href="#">5441</a>	POLR2L	RNA polymerase II subunit L	3
<a href="#">55272</a>	IMP3	IMP3, U3 small nucleolar ribonucleoprotein	3
<a href="#">11047</a>	ADRM1	adhesion regulating molecule 1	3
<a href="#">23170</a>	TTLL12	tubulin tyrosine ligase like 12	3
<a href="#">53354</a>	PANK1	pantothenate kinase 1	3
<a href="#">3692</a>	EIF6	eukaryotic translation initiation factor 6	3
<a href="#">5709</a>	PSMD3	proteasome 26S subunit, non-ATPase 3	3
<a href="#">23543</a>	RBFOX2	RNA binding protein, fox-1 homolog 2	3
<a href="#">56834</a>	GPR137	G protein-coupled receptor 137	3
<a href="#">8402</a>	SLC25A11	solute carrier family 25 member 11	3
<a href="#">5694</a>	PSMB6	proteasome subunit beta 6	3
<a href="#">10113</a>	PREB	prolactin regulatory element binding	3
<a href="#">26073</a>	POLDIP2	DNA polymerase delta interacting protein 2	3
<a href="#">28989</a>	NTMT1	N-terminal Xaa-Pro-Lys N-methyltransferase 1	3
<a href="#">55856</a>	ACOT13	acyl-CoA thioesterase 13	3
<a href="#">29934</a>	SNX12	sorting nexin 12	3
<a href="#">23645</a>	PPP1R15A	protein phosphatase 1 regulatory subunit 15A	3
<a href="#">51278</a>	IER5	immediate early response 5	3
<a href="#">10063</a>	COX17	COX17, cytochrome c oxidase copper chaperone	3
<a href="#">83706</a>	FERMT3	fermitin family member 3	3
<a href="#">54973</a>	CPSF3L	cleavage and polyadenylation specific factor 3-like	3
<a href="#">401466</a>	C8orf59	chromosome 8 open reading frame 59	3
<a href="#">84287</a>	ZDHHC16	zinc finger DHHC-type containing 16	3
<a href="#">10257</a>	ABCC4	ATP binding cassette subfamily C member 4	3
<a href="#">23466</a>	CBX6	chromobox 6	3
<a href="#">64965</a>	MRPS9	mitochondrial ribosomal protein S9	3
<a href="#">51097</a>	SCCPDH	saccharopine dehydrogenase (putative)	3
<a href="#">51659</a>	GINS2	GINS complex subunit 2	3
<a href="#">6434</a>	TRA2B	transformer 2 beta homolog (Drosophila)	3
		5-aminoimidazole-4-carboxamide ribonucleotide formyltransferase/IMP	
<a href="#">471</a>	ATIC	cyclohydrolase	3
<a href="#">23074</a>	UHRF1BP1L	UHRF1 binding protein 1 like	3
<a href="#">10598</a>	AHSA1	activator of Hsp90 ATPase activity 1	3
<a href="#">1653</a>	DDX1	DEAD/H-box helicase 1	3
<a href="#">57695</a>	USP37	ubiquitin specific peptidase 37	3
<a href="#">3840</a>	KPNA4	karyopherin subunit alpha 4	3
<a href="#">54517</a>	PUS7	pseudouridylate synthase 7 (putative)	3
<a href="#">8870</a>	IER3	immediate early response 3	3
<a href="#">9761</a>	MLEC	malectin	3
<a href="#">116225</a>	ZMYND19	zinc finger MYND-type containing 19	3
<a href="#">6183</a>	MRPS12	mitochondrial ribosomal protein S12	3
<a href="#">9308</a>	CD83	CD83 molecule	3
<a href="#">10061</a>	ABCF2	ATP binding cassette subfamily F member 2	3
<a href="#">6484</a>	ST3GAL4	ST3 beta-galactoside alpha-2,3-sialyltransferase 4	3

<a href="#">283742</a>	FAM98B	family with sequence similarity 98 member B	3
<a href="#">27158</a>	NDOR1	NADPH dependent diflavin oxidoreductase 1	3
<a href="#">126792</a>	B3GALT6	beta-1,3-galactosyltransferase 6	3
<a href="#">51400</a>	PPME1	protein phosphatase methylesterase 1	3
<a href="#">10694</a>	CCT8	chaperonin containing TCP1 subunit 8	3
<a href="#">29090</a>	TIMM21	translocase of inner mitochondrial membrane 21	3
<a href="#">4670</a>	HNRNPM	heterogeneous nuclear ribonucleoprotein M	3
<a href="#">10988</a>	METAP2	methionyl aminopeptidase 2	3
<a href="#">9868</a>	TOMM70	translocase of outer mitochondrial membrane 70	3
<a href="#">1431</a>	CS	citrate synthase	3
<a href="#">3157</a>	HMGCS1	3-hydroxy-3-methylglutaryl-CoA synthase 1	3
<a href="#">11112</a>	HIBADH	3-hydroxyisobutyrate dehydrogenase	3
<a href="#">10213</a>	PSMD14	proteasome 26S subunit, non-ATPase 14	3
<a href="#">1434</a>	CSE1L	chromosome segregation 1 like	3
<a href="#">51081</a>	MRPS7	mitochondrial ribosomal protein S7	3
<a href="#">23590</a>	PDSS1	prenyl (decaprenyl) diphosphate synthase, subunit 1	3
<a href="#">6749</a>	SSRP1	structure specific recognition protein 1	3
<a href="#">3562</a>	IL3	interleukin 3	3
<a href="#">10189</a>	ALYREF	Aly/REF export factor	3
<a href="#">6431</a>	SRSF6	serine and arginine rich splicing factor 6	3
<a href="#">292</a>	SLC25A5	solute carrier family 25 member 5	3
<a href="#">23160</a>	WDR43	WD repeat domain 43	3
<a href="#">2030</a>	SLC29A1	solute carrier family 29 member 1 (Augustine blood group)	3
<a href="#">5536</a>	PPP5C	protein phosphatase 5 catalytic subunit	3
<a href="#">9188</a>	DDX21	DEAD-box helicase 21	3
<a href="#">8726</a>	EED	embryonic ectoderm development	3
<a href="#">29889</a>	GNL2	G protein nucleolar 2	3
<a href="#">4436</a>	MSH2	mutS homolog 2	3
<a href="#">4175</a>	MCM6	minichromosome maintenance complex component 6	3
<a href="#">10939</a>	AFG3L2	AFG3 like matrix AAA peptidase subunit 2	3
<a href="#">1994</a>	ELAVL1	ELAV like RNA binding protein 1	3
<a href="#">23450</a>	SF3B3	splicing factor 3b subunit 3	3
<a href="#">29781</a>	NCAPH2	non-SMC condensin II complex subunit H2	3
<a href="#">5707</a>	PSMD1	proteasome 26S subunit, non-ATPase 1	3
<a href="#">10657</a>	KHDRBS1	KH RNA binding domain containing, signal transduction associated 1	3
<a href="#">10432</a>	RBM14	RNA binding motif protein 14	3
<a href="#">7518</a>	XRCC4	X-ray repair cross complementing 4	3
<a href="#">3301</a>	DNAJA1	DnaJ heat shock protein family (Hsp40) member A1	3
<a href="#">2935</a>	GSPT1	G1 to S phase transition 1	3
<a href="#">1982</a>	EIF4G2	eukaryotic translation initiation factor 4 gamma 2	3
<a href="#">3184</a>	HNRNPD	heterogeneous nuclear ribonucleoprotein D	3
<a href="#">23082</a>	PPRC1	peroxisome proliferator-activated receptor gamma, coactivator-related 1	3
<a href="#">27089</a>	UQCRQ	ubiquinol-cytochrome c reductase complex III subunit VII	3
<a href="#">7165</a>	TPD52L2	tumor protein D52 like 2	3
<a href="#">29098</a>	RANGRF	RAN guanine nucleotide release factor	3
<a href="#">8260</a>	NAA10	N(alpha)-acetyltransferase 10, NatA catalytic subunit	3
<a href="#">51373</a>	MRPS17	mitochondrial ribosomal protein S17	3
<a href="#">1892</a>	ECHS1	enoyl-CoA hydratase, short chain 1	3
<a href="#">22868</a>	FASTKD2	FAST kinase domains 2	3
<a href="#">5931</a>	RBBP7	RB binding protein 7, chromatin remodeling factor	3
<a href="#">84135</a>	UTP15	UTP15, small subunit processome component	3
<a href="#">23165</a>	NUP205	nucleoporin 205	3
<a href="#">5202</a>	PFDN2	prefoldin subunit 2	3
<a href="#">84331</a>	MCRIP2	MAPK regulated corepressor interacting protein 2	3
<a href="#">705</a>	BYSL	bystin like	3
<a href="#">3622</a>	ING2	inhibitor of growth family member 2	3
<a href="#">9631</a>	NUP155	nucleoporin 155	3
<a href="#">79711</a>	IPO4	importin 4	3
<a href="#">1660</a>	DHX9	DEAH-box helicase 9	3
<a href="#">7372</a>	UMPS	uridine monophosphate synthetase	3
<a href="#">199953</a>	TMEM201	transmembrane protein 201	3
<a href="#">3068</a>	HDGF	hepatoma-derived growth factor	3
<a href="#">10295</a>	BCKDK	branched chain ketoacid dehydrogenase kinase	3
<a href="#">144097</a>	C11orf84	chromosome 11 open reading frame 84	3
<a href="#">4628</a>	MYH10	myosin heavy chain 10	3
<a href="#">84649</a>	DGAT2	diacylglycerol O-acyltransferase 2	3

<a href="#">516</a>	ATP5G1	ATP synthase, H <sup>+</sup> transporting, mitochondrial Fo complex subunit C1 (subunit 9)	3
<a href="#">5719</a>	PSMD13	proteasome 26S subunit, non-ATPase 13	3
<a href="#">1212</a>	CLTB	clathrin light chain B	3
<a href="#">8882</a>	ZPR1	ZPR1 zinc finger	3
<a href="#">10430</a>	TMEM147	transmembrane protein 147	3
<a href="#">10534</a>	SSSCA1	Sjogren syndrome/scleroderma autoantigen 1	3
<a href="#">8664</a>	EIF3D	eukaryotic translation initiation factor 3 subunit D	3
<a href="#">79572</a>	ATP13A3	ATPase 13A3	3
<a href="#">10452</a>	TOMM40	translocase of outer mitochondrial membrane 40	3
<a href="#">3615</a>	IMPDH2	inosine monophosphate dehydrogenase 2	3
<a href="#">85476</a>	GFM1	G elongation factor mitochondrial 1	3
<a href="#">10575</a>	CCT4	chaperonin containing TCP1 subunit 4	3
<a href="#">2184</a>	FAH	fumarylacetoacetate hydrolase	3
<a href="#">201161</a>	CENPV	centromere protein V	3
<a href="#">121053</a>	C12orf45	chromosome 12 open reading frame 45	3
<a href="#">5198</a>	PFAS	phosphoribosylformylglycinamide synthase	3
<a href="#">113419</a>	TEX261	testis expressed 261	3
<a href="#">3308</a>	HSPA4	heat shock protein family A (Hsp70) member 4	3
<a href="#">9654</a>	TTL4	tubulin tyrosine ligase like 4	3
<a href="#">23</a>	ABCF1	ATP binding cassette subfamily F member 1	3
<a href="#">4171</a>	MCM2	minichromosome maintenance complex component 2	3
<a href="#">9929</a>	JOSD1	Josephin domain containing 1	3
<a href="#">949</a>	SCARB1	scavenger receptor class B member 1	3
<a href="#">192111</a>	PGAM5	PGAM family member 5, mitochondrial serine/threonine protein phosphatase	3
<a href="#">23277</a>	CLUH	clustered mitochondria homolog	3
<a href="#">27042</a>	DIEXF	digestive organ expansion factor homolog (zebrafish)	3
<a href="#">10155</a>	TRIM28	tripartite motif containing 28	3
<a href="#">54919</a>	DNAAF5	dynein axonemal assembly factor 5	3
<a href="#">7517</a>	XRCC3	X-ray repair cross complementing 3	3
<a href="#">4174</a>	MCM5	minichromosome maintenance complex component 5	3
<a href="#">84817</a>	TXNDC17	thioredoxin domain containing 17	3
<a href="#">5434</a>	POLR2E	RNA polymerase II subunit E	3
<a href="#">9146</a>	HGS	hepatocyte growth factor-regulated tyrosine kinase substrate	3
<a href="#">79709</a>	COLGALT1	collagen beta(1-O)galactosyltransferase 1	3
<a href="#">2802</a>	GOLGA3	golgin A3	3
<a href="#">2706</a>	GJB2	gap junction protein beta 2	3
<a href="#">55120</a>	FANCL	Fanconi anemia complementation group L	3
<a href="#">25885</a>	POLR1A	RNA polymerase I subunit A	3
<a href="#">54107</a>	POLE3	DNA polymerase epsilon 3, accessory subunit	3
<a href="#">57464</a>	STRIP2	striatin interacting protein 2	3
<a href="#">1848</a>	DUSP6	dual specificity phosphatase 6	3
<a href="#">154807</a>	VKORC1L1	vitamin K epoxide reductase complex subunit 1 like 1	3
<a href="#">127396</a>	ZNF684	zinc finger protein 684	3
<a href="#">222229</a>	LRWD1	leucine rich repeats and WD repeat domain containing 1	3
<a href="#">351</a>	APP	amyloid beta precursor protein	3
<a href="#">63932</a>	CXorf56	chromosome X open reading frame 56	3
<a href="#">65108</a>	MARCKSL1	MARCKS like 1	3
<a href="#">23413</a>	NCS1	neuronal calcium sensor 1	3
<a href="#">2963</a>	GTF2F2	general transcription factor IIF subunit 2	3
<a href="#">548645</a>	DNAJC25	DnaJ heat shock protein family (Hsp40) member C25	3
<a href="#">56655</a>	POLE4	DNA polymerase epsilon 4, accessory subunit	3
<a href="#">7532</a>	YWHAQ	tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein gamma	3
<a href="#">84326</a>	METTL26	methyltransferase like 26	3
<a href="#">51259</a>	TMEM216	transmembrane protein 216	3
<a href="#">8662</a>	EIF3B	eukaryotic translation initiation factor 3 subunit B	3
<a href="#">14</a>	AAMP	angio associated migratory cell protein	3
<a href="#">29893</a>	PSMC3IP	PSMC3 interacting protein	3
<a href="#">55142</a>	HAUS2	HAUS augmin like complex subunit 2	3
<a href="#">10204</a>	NUTF2	nuclear transport factor 2	3
<a href="#">81620</a>	CDT1	chromatin licensing and DNA replication factor 1	3
<a href="#">11072</a>	DUSP14	dual specificity phosphatase 14	3
<a href="#">10538</a>	BATF	basic leucine zipper ATF-like transcription factor	3
<a href="#">1022</a>	CDK7	cyclin dependent kinase 7	3
<a href="#">79080</a>	CCDC86	coiled-coil domain containing 86	3
<a href="#">64979</a>	MRPL36	mitochondrial ribosomal protein L36	3

<a href="#">112812</a>	FDX1L	ferredoxin 1 like	3
<a href="#">1642</a>	DDB1	damage specific DNA binding protein 1	3
<a href="#">84262</a>	PSMG3	proteasome assembly chaperone 3	3
<a href="#">55862</a>	ECHDC1	ethylmalonyl-CoA decarboxylase 1	3
<a href="#">64785</a>	GINS3	GINS complex subunit 3	3
<a href="#">5438</a>	POLR2I	RNA polymerase II subunit I	3
<a href="#">286</a>	ANK1	ankyrin 1	3
<a href="#">51534</a>	VTA1	vesicle trafficking 1	3
<a href="#">2717</a>	GLA	galactosidase alpha	3
<a href="#">84916</a>	UTP4	UTP4, small subunit processome component	3
<a href="#">64963</a>	MRPS11	mitochondrial ribosomal protein S11	3
<a href="#">6351</a>	CCL4	C-C motif chemokine ligand 4	3
<a href="#">79022</a>	TMEM106C	transmembrane protein 106C	3
<a href="#">8395</a>	PIP5K1B	phosphatidylinositol-4-phosphate 5-kinase type 1 beta	3
<a href="#">4809</a>	SNU13	SNU13 homolog, small nuclear ribonucleoprotein (U4/U6.U5)	3
<a href="#">60673</a>	ATG101	autophagy related 101	3
<a href="#">29105</a>	CFAP20	cilia and flagella associated protein 20	3
<a href="#">114971</a>	PTPMT1	protein tyrosine phosphatase, mitochondrial 1	3
<a href="#">27020</a>	NPTN	neuroplastin	3
<a href="#">10248</a>	POP7	POP7 homolog, ribonuclease P/MRP subunit	3
<a href="#">9775</a>	EIF4A3	eukaryotic translation initiation factor 4A3	3
<a href="#">79155</a>	TNIP2	TNFAIP3 interacting protein 2	3
<a href="#">1211</a>	CLTA	clathrin light chain A	3
<a href="#">5693</a>	PSMB5	proteasome subunit beta 5	3
<a href="#">7262</a>	PHLDA2	pleckstrin homology like domain family A member 2	3
<a href="#">131566</a>	DCBLD2	discoidin, CUB and LCCL domain containing 2	3
<a href="#">29902</a>	FAM216A	family with sequence similarity 216 member A	3
<a href="#">51013</a>	EXOSC1	exosome component 1	3
<a href="#">27309</a>	ZNF330	zinc finger protein 330	3
<a href="#">64983</a>	MRPL32	mitochondrial ribosomal protein L32	3
<a href="#">5036</a>	PA2G4	proliferation-associated 2G4	3
<a href="#">51010</a>	EXOSC3	exosome component 3	3
<a href="#">147184</a>	TMEM99	transmembrane protein 99	3
<a href="#">60314</a>	C12orf10	chromosome 12 open reading frame 10	3
<a href="#">79590</a>	MRPL24	mitochondrial ribosomal protein L24	3
<a href="#">154467</a>	CCDC167	coiled-coil domain containing 167	3
<a href="#">483</a>	ATP1B3	ATPase Na <sup>+</sup> /K <sup>+</sup> transporting subunit beta 3	3
<a href="#">282991</a>	BLOC1S2	biogenesis of lysosomal organelles complex 1 subunit 2	3
<a href="#">10322</a>	SMYD5	SMYD family member 5	3
<a href="#">4000</a>	LMNA	lamin A/C	3
<a href="#">1497</a>	CTNS	cystinosis, lysosomal cystine transporter	3
<a href="#">51073</a>	MRPL4	mitochondrial ribosomal protein L4	3
<a href="#">6449</a>	SGTA	small glutamine rich tetratricopeptide repeat containing alpha	3
<a href="#">10186</a>	LHFP	lipoma HMGIC fusion partner	3
<a href="#">55847</a>	CISD1	CDGSH iron sulfur domain 1	3
<a href="#">25940</a>	FAM98A	family with sequence similarity 98 member A	3
<a href="#">9861</a>	PSMD6	proteasome 26S subunit, non-ATPase 6	3
<a href="#">356</a>	FASLG	Fas ligand	3
<a href="#">79077</a>	DCTPP1	dCTP pyrophosphatase 1	3
<a href="#">57514</a>	ARHGAP31	Rho GTPase activating protein 31	3
<a href="#">84259</a>	DCUN1D5	defective in cullin neddylation 1 domain containing 5	3
<a href="#">1104</a>	RCC1	regulator of chromosome condensation 1	3
<a href="#">54555</a>	DDX49	DEAD-box helicase 49	3
<a href="#">84769</a>	MPV17L2	MPV17 mitochondrial inner membrane protein like 2	3
<a href="#">119559</a>	SFXN4	sideroflexin 4	3
<a href="#">55968</a>	NSFL1C	NSFL1 cofactor	3
<a href="#">3066</a>	HDAC2	histone deacetylase 2	3
<a href="#">1984</a>	EIF5A	eukaryotic translation initiation factor 5A	3
<a href="#">4792</a>	NFKBIA	NFKB inhibitor alpha	3
<a href="#">7314</a>	UBB	ubiquitin B	3
<a href="#">5704</a>	PSMC4	proteasome 26S subunit, ATPase 4	3
<a href="#">125144</a>	LRRC75A-AS1	LRRC75A antisense RNA 1	3
<a href="#">50486</a>	GOS2	G0/G1 switch 2	3
<a href="#">54955</a>	C1orf109	chromosome 1 open reading frame 109	3
<a href="#">25804</a>	LSM4	LSM4 homolog, U6 small nuclear RNA and mRNA degradation associated	3

<a href="#">51021</a>	MRPS16	mitochondrial ribosomal protein S16	3
<a href="#">54475</a>	NLE1	notchless homolog 1	3
<a href="#">56915</a>	EXOSC5	exosome component 5	3
<a href="#">92579</a>	G6PC3	glucose-6-phosphatase catalytic subunit 3	3
<a href="#">2590</a>	GALNT2	polypeptide N-acetylgalactosaminyltransferase 2	3
<a href="#">54663</a>	WDR74	WD repeat domain 74	3
<a href="#">4201</a>	MEA1	male-enhanced antigen 1	3
<a href="#">3558</a>	IL2	interleukin 2	3
<a href="#">5250</a>	SLC25A3	solute carrier family 25 member 3	3
<a href="#">1844</a>	DUSP2	dual specificity phosphatase 2	3
<a href="#">5326</a>	PLAGL2	PLAG1 like zinc finger 2	3
<a href="#">83596</a>	BCL2L12	BCL2 like 12	3
<a href="#">84285</a>	EIF1AD	eukaryotic translation initiation factor 1A domain containing	3
<a href="#">5245</a>	PHB	prohibitin	3
<a href="#">27351</a>	DES11	desumoylating isopeptidase 1	3
<a href="#">5902</a>	RANBP1	RAN binding protein 1	3
<a href="#">54982</a>	CLN6	ceroid-lipofuscinosis, neuronal 6, late infantile, variant	3
<a href="#">5725</a>	PTBP1	polypyrimidine tract binding protein 1	3
<a href="#">30000</a>	TNPO2	transportin 2	3
<a href="#">51144</a>	HSD17B12	hydroxysteroid 17-beta dehydrogenase 12	3
<a href="#">5552</a>	SRGN	serglycin	3
<a href="#">5251</a>	PHEX	phosphate regulating endopeptidase homolog, X-linked	3
<a href="#">4953</a>	ODC1	ornithine decarboxylase 1	3
<a href="#">8740</a>	TNFSF14	tumor necrosis factor superfamily member 14	3
<a href="#">6723</a>	SRM	spermidine synthase	3
<a href="#">55352</a>	COPRS	coordinator of PRMT5 and differentiation stimulator	3
<a href="#">7866</a>	IFRD2	interferon related developmental regulator 2	3
<a href="#">23076</a>	RRP1B	ribosomal RNA processing 1B	3
<a href="#">112464</a>	PRKCDDBP	protein kinase C delta binding protein	3
<a href="#">66005</a>	CHID1	chitinase domain containing 1	3
<a href="#">388962</a>	BOLA3	boLA family member 3	3
<a href="#">7293</a>	TNFRSF4	TNF receptor superfamily member 4	3
<a href="#">4927</a>	NUP88	nucleoporin 88	3
<a href="#">3002</a>	GZMB	granzyme B	3
<a href="#">3559</a>	IL2RA	interleukin 2 receptor subunit alpha	3
<a href="#">79033</a>	ERI3	ERI1 exoribonuclease family member 3	3
<a href="#">494143</a>	CHAC2	ChaC cation transport regulator homolog 2	3
<a href="#">84833</a>	USMG5	up-regulated during skeletal muscle growth 5 homolog (mouse)	3
<a href="#">7283</a>	TUBG1	tubulin gamma 1	3
<a href="#">51371</a>	POMP	proteasome maturation protein	3
<a href="#">51605</a>	TRMT6	tRNA methyltransferase 6	3
<a href="#">54865</a>	GPATCH4	G-patch domain containing 4	3
<a href="#">219927</a>	MRPL21	mitochondrial ribosomal protein L21	3
<a href="#">2091</a>	FBL	fibrillarin	3
<a href="#">5695</a>	PSMB7	proteasome subunit beta 7	3
<a href="#">1460</a>	CSNK2B	casein kinase 2 beta	3
<a href="#">7965</a>	AIMP2	aminoacyl tRNA synthetase complex interacting multifunctional protein 2	3
<a href="#">200916</a>	RPL22L1	ribosomal protein L22 like 1	3
<a href="#">4700</a>	NDUFA6	NADH:ubiquinone oxidoreductase subunit A6	3
<a href="#">10549</a>	PRDX4	peroxiredoxin 4	3
<a href="#">84807</a>	NFKBID	NFKB inhibitor delta	3
<a href="#">2288</a>	FKBP4	FK506 binding protein 4	3
<a href="#">3276</a>	PRMT1	protein arginine methyltransferase 1	3
<a href="#">60488</a>	MRPS35	mitochondrial ribosomal protein S35	3
<a href="#">23481</a>	PES1	pescadillo ribosomal biogenesis factor 1	3
<a href="#">196383</a>	RILPL2	Rab interacting lysosomal protein like 2	3
<a href="#">2224</a>	FDPS	farnesyl diphosphate synthase	3
<a href="#">55003</a>	PAK1IP1	PAK1 interacting protein 1	3
<a href="#">126382</a>	NR2C2AP	nuclear receptor 2C2 associated protein	3
<a href="#">51504</a>	TRMT112	tRNA methyltransferase 11-2 homolog (S. cerevisiae)	3
<a href="#">92609</a>	TIMM50	translocase of inner mitochondrial membrane 50	3
<a href="#">708</a>	C1QBP	complement C1q binding protein	3
<a href="#">10327</a>	AKR1A1	aldo-keto reductase family 1 member A1	3
<a href="#">6921</a>	TCEB1	transcription elongation factor B subunit 1	3
<a href="#">26517</a>	TIMM13	translocase of inner mitochondrial membrane 13	3

<a href="#">84313</a>	VPS25	vacuolar protein sorting 25 homolog	3
<a href="#">63875</a>	MRPL17	mitochondrial ribosomal protein L17	3
<a href="#">5435</a>	POLR2F	RNA polymerase II subunit F	3
<a href="#">79833</a>	GEMIN6	gem nuclear organelle associated protein 6	3
<a href="#">1736</a>	DKC1	dyskerin pseudouridine synthase 1	3
<a href="#">23560</a>	GTPBP4	GTP binding protein 4	3
<a href="#">7371</a>	UCK2	uridine-cytidine kinase 2	3
<a href="#">3182</a>	HNRNPAB	heterogeneous nuclear ribonucleoprotein A/B	3
<a href="#">4691</a>	NCL	nucleolin	3
<a href="#">56902</a>	PNO1	partner of NOB1 homolog	3
<a href="#">3313</a>	HSPA9	heat shock protein family A (Hsp70) member 9	3
<a href="#">1019</a>	CDK4	cyclin dependent kinase 4	3
<a href="#">5901</a>	RAN	RAN, member RAS oncogene family	3
<a href="#">10528</a>	NOP56	NOP56 ribonucleoprotein	3
<a href="#">29015</a>	SLC43A3	solute carrier family 43 member 3	3
<a href="#">25819</a>	NOCT	nocturnin	3
<a href="#">26230</a>	TIAM2	T-cell lymphoma invasion and metastasis 2	3
<a href="#">10969</a>	EBNA1BP2	EBNA1 binding protein 2	3
<a href="#">10135</a>	NAMPT	nicotinamide phosphoribosyltransferase	3
<a href="#">10196</a>	PRMT3	protein arginine methyltransferase 3	3
<a href="#">6626</a>	SNRPA	small nuclear ribonucleoprotein polypeptide A	3
<a href="#">8668</a>	EIF3I	eukaryotic translation initiation factor 3 subunit I	3
<a href="#">113174</a>	SAAL1	serum amyloid A like 1	3
<a href="#">54984</a>	PINX1	PIN2/TERF1 interacting, telomerase inhibitor 1	3
<a href="#">6636</a>	SNRPF	small nuclear ribonucleoprotein polypeptide F	3
<a href="#">5052</a>	PRDX1	peroxiredoxin 1	3
<a href="#">51493</a>	RTCB	RNA 2',3'-cyclic phosphate and 5'-OH ligase	3
<a href="#">3608</a>	ILF2	interleukin enhancer binding factor 2	3
<a href="#">11091</a>	WDR5	WD repeat domain 5	3
<a href="#">10056</a>	FARSB	phenylalanyl-tRNA synthetase beta subunit	3
<a href="#">10492</a>	SYNCRIP	synaptotagmin binding cytoplasmic RNA interacting protein	3
<a href="#">8061</a>	FOSL1	FOS like 1, AP-1 transcription factor subunit	3
<a href="#">3329</a>	HSPD1	heat shock protein family D (Hsp60) member 1	3
<a href="#">9221</a>	NOLC1	nucleolar and coiled-body phosphoprotein 1	3
<a href="#">6631</a>	SNRPC	small nuclear ribonucleoprotein polypeptide C	3
<a href="#">7416</a>	VDAC1	voltage dependent anion channel 1	3
<a href="#">1647</a>	GADD45A	growth arrest and DNA damage inducible alpha	3
<a href="#">3605</a>	IL17A	interleukin 17A	3
<a href="#">617</a>	BCS1L	BCS1 homolog, ubiquinol-cytochrome c reductase complex chaperone	3
<a href="#">93436</a>	ARMC6	armadillo repeat containing 6	3
<a href="#">10227</a>	MFSD10	major facilitator superfamily domain containing 10	3
<a href="#">55624</a>	POMGNT1	protein O-linked mannose N-acetylglucosaminyltransferase 1 (beta 1,2-)	3
<a href="#">64768</a>	IPPK	inositol-pentakisphosphate 2-kinase	3
<a href="#">126321</a>	MFSD12	major facilitator superfamily domain containing 12	3
<a href="#">8192</a>	CLPP	caseinolytic mitochondrial matrix peptidase proteolytic subunit	3
<a href="#">84300</a>	UQCC2	ubiquinol-cytochrome c reductase complex assembly factor 2	3
<a href="#">10244</a>	RABEPK	Rab9 effector protein with kelch motifs	3
<a href="#">57819</a>	LSM2	LSM2 homolog, U6 small nuclear RNA and mRNA degradation associated	3
<a href="#">28958</a>	COA3	cytochrome c oxidase assembly factor 3	3
<a href="#">2109</a>	ETFB	electron transfer flavoprotein beta subunit	3
<a href="#">11266</a>	DUSP12	dual specificity phosphatase 12	3
<a href="#">51474</a>	LIMA1	LIM domain and actin binding 1	3
<a href="#">4731</a>	NDUFV3	NADH:ubiquinone oxidoreductase subunit V3	3
<a href="#">4701</a>	NDUFA7	NADH:ubiquinone oxidoreductase subunit A7	3
<a href="#">9238</a>	TBRG4	transforming growth factor beta regulator 4	3
<a href="#">29080</a>	CCDC59	coiled-coil domain containing 59	3
<a href="#">29985</a>	SLC39A3	solute carrier family 39 member 3	3
<a href="#">1537</a>	CYC1	cytochrome c1	3
<a href="#">8784</a>	TNFRSF18	TNF receptor superfamily member 18	3
<a href="#">9526</a>	MPDU1	mannose-P-dolichol utilization defect 1	3
<a href="#">26121</a>	PRPF31	pre-mRNA processing factor 31	3
<a href="#">977</a>	CD151	CD151 molecule (Raph blood group)	3
<a href="#">83460</a>	EMC6	ER membrane protein complex subunit 6	3
<a href="#">64960</a>	MRPS15	mitochondrial ribosomal protein S15	3
<a href="#">2950</a>	GSTP1	glutathione S-transferase pi 1	3

<a href="#">112939</a>	NACC1	nucleus accumbens associated 1	3
<a href="#">51293</a>	CD320	CD320 molecule	3
<a href="#">5119</a>	CHMP1A	charged multivesicular body protein 1A	3
<a href="#">8886</a>	DDX18	DEAD-box helicase 18	3
<a href="#">8818</a>	DPM2	dolichyl-phosphate mannosyltransferase subunit 2, regulatory	3
<a href="#">26519</a>	TIMM10	translocase of inner mitochondrial membrane 10 homolog (yeast)	3
<a href="#">4236</a>	MFAP1	microfibrillar associated protein 1	3
<a href="#">5214</a>	PFKP	phosphofructokinase, platelet	3
<a href="#">79894</a>	ZNF672	zinc finger protein 672	3
<a href="#">51116</a>	MRPS2	mitochondrial ribosomal protein S2	3
<a href="#">29950</a>	SERTAD1	SERTA domain containing 1	3
<a href="#">23399</a>	CTDNEP1	CTD nuclear envelope phosphatase 1	3
<a href="#">54881</a>	TEX10	testis expressed 10	3
<a href="#">10245</a>	TIMM17B	translocase of inner mitochondrial membrane 17 homolog B (yeast)	3
<a href="#">51236</a>	HGH1	HGH1 homolog	3
<a href="#">55697</a>	VAC14	Vac14, PIKFYVE complex component	3
<a href="#">27183</a>	VPS4A	vacuolar protein sorting 4 homolog A	3
<a href="#">5394</a>	EXOSC10	exosome component 10	3
<a href="#">55157</a>	DARS2	aspartyl-tRNA synthetase 2, mitochondrial	3
<a href="#">3726</a>	JUNB	JunB proto-oncogene, AP-1 transcription factor subunit	3
<a href="#">3281</a>	HSBP1	heat shock factor binding protein 1	3
<a href="#">55658</a>	RNF126	ring finger protein 126	3
<a href="#">9455</a>	HOMER2	homer scaffolding protein 2	3
<a href="#">345630</a>	FBLL1	fibrillarin-like 1	3
<a href="#">29923</a>	HILPDA	hypoxia inducible lipid droplet associated	3
<a href="#">54968</a>	TMEM70	transmembrane protein 70	3
<a href="#">84002</a>	B3GNT5	UDP-GlcNAc:betaGal beta-1,3-N-acetylglucosaminyltransferase 5	3
<a href="#">10573</a>	MRPL28	mitochondrial ribosomal protein L28	3
<a href="#">55168</a>	MRPS18A	mitochondrial ribosomal protein S18A	3
<a href="#">4817</a>	NIT1	nitrilase 1	3
<a href="#">7247</a>	TSN	translin	3
<a href="#">54148</a>	MRPL39	mitochondrial ribosomal protein L39	3
<a href="#">29100</a>	TMEM208	transmembrane protein 208	3
<a href="#">9326</a>	ZNHIT3	zinc finger HIT-type containing 3	3
<a href="#">5682</a>	PSMA1	proteasome subunit alpha 1	3
<a href="#">64708</a>	COPS7B	COP9 signalosome subunit 7B	3
<a href="#">6415</a>	SELENOW	selenoprotein W	3
<a href="#">10069</a>	RWDD2B	RWD domain containing 2B	3
<a href="#">54840</a>	APTX	aprataxin	3
<a href="#">112495</a>	GTF3C6	general transcription factor IIIC subunit 6	3
<a href="#">10102</a>	TSFM	Ts translation elongation factor, mitochondrial	3
<a href="#">29097</a>	CNIH4	cornichon family AMPA receptor auxiliary protein 4	3
<a href="#">9391</a>	CIAO1	cytosolic iron-sulfur assembly component 1	3
<a href="#">221143</a>	EEF1AKMT1	eukaryotic translation elongation factor 1 alpha lysine methyltransferase 1	3
<a href="#">4116</a>	MAGOH	mago homolog, exon junction complex core component	3
<a href="#">54887</a>	UHRF1BP1	UHRF1 binding protein 1	3
<a href="#">128553</a>	TSHZ2	teashirt zinc finger homeobox 2	3
<a href="#">9088</a>	PKMYT1	protein kinase, membrane associated tyrosine/threonine 1	3
<a href="#">51154</a>	MRTO4	MRT4 homolog, ribosome maturation factor	3
<a href="#">10131</a>	TRAP1	TNF receptor associated protein 1	3
<a href="#">63933</a>	MCUR1	mitochondrial calcium uniporter regulator 1	3
<a href="#">10212</a>	DDX39A	DEAD-box helicase 39A	3
<a href="#">51714</a>	SELENOT	selenoprotein T	3
<a href="#">4191</a>	MDH2	malate dehydrogenase 2	3
<a href="#">10498</a>	CARM1	coactivator associated arginine methyltransferase 1	3
<a href="#">5817</a>	PVR	poliovirus receptor	3
<a href="#">80764</a>	THAP7	THAP domain containing 7	3
<a href="#">2193</a>	FARSA	phenylalanyl-tRNA synthetase alpha subunit	3
<a href="#">7284</a>	TUFM	Tu translation elongation factor, mitochondrial	3
<a href="#">5426</a>	POLE	DNA polymerase epsilon, catalytic subunit	3
<a href="#">5962</a>	RDX	radixin	3
<a href="#">10785</a>	WDR4	WD repeat domain 4	3
<a href="#">27101</a>	CACYBP	calyculin binding protein	3
<a href="#">23291</a>	FBXW11	F-box and WD repeat domain containing 11	3
<a href="#">2632</a>	GBE1	1,4-alpha-glucan branching enzyme 1	3

<a href="#">84172</a>	POLR1B	RNA polymerase I subunit B	3
<a href="#">55324</a>	ABCF3	ATP binding cassette subfamily F member 3	3
<a href="#">60625</a>	DHX35	DEAH-box helicase 35	3
<a href="#">8815</a>	BANF1	barrier to autointegration factor 1	3
<a href="#">9937</a>	DCLRE1A	DNA cross-link repair 1A	3
<a href="#">10980</a>	COPS6	COP9 signalosome subunit 6	3
<a href="#">27069</a>	GHITM	growth hormone inducible transmembrane protein	3
<a href="#">2827</a>	GPR3	G protein-coupled receptor 3	3
<a href="#">5432</a>	POLR2C	RNA polymerase II subunit C	3
<a href="#">7458</a>	EIF4H	eukaryotic translation initiation factor 4H	3
<a href="#">51499</a>	TRIAF1	TP53 regulated inhibitor of apoptosis 1	3
<a href="#">5781</a>	PTPN11	protein tyrosine phosphatase, non-receptor type 11	3
<a href="#">53</a>	ACP2	acid phosphatase 2, lysosomal	3
<a href="#">653122</a>	LSM12P1	LSM12 pseudogene 1	3
<a href="#">94081</a>	SFXN1	sideroflexin 1	3
<a href="#">8125</a>	ANP32A	acidic nuclear phosphoprotein 32 family member A	3
<a href="#">3312</a>	HSPA8	heat shock protein family A (Hsp70) member 8	3
<a href="#">54994</a>	GID8	GID complex subunit 8 homolog	3
<a href="#">8898</a>	MTMR2	myotubularin related protein 2	3
<a href="#">5905</a>	RANGAP1	Ran GTPase activating protein 1	3
<a href="#">23141</a>	ANKLE2	ankyrin repeat and LEM domain containing 2	3
<a href="#">196483</a>	EEF2KMT	eukaryotic elongation factor 2 lysine methyltransferase	3
<a href="#">65083</a>	NOL6	nucleolar protein 6	3
<a href="#">51001</a>	MTERF3	mitochondrial transcription termination factor 3	3
<a href="#">51537</a>	MTFP1	mitochondrial fission process 1	3
<a href="#">64065</a>	PERP	PERP, TP53 apoptosis effector	3
<a href="#">6428</a>	SRSF3	serine and arginine rich splicing factor 3	3
<a href="#">60592</a>	SCOC	short coiled-coil protein	3
<a href="#">58477</a>	SRPRB	SRP receptor beta subunit	3
<a href="#">51015</a>	ISOC1	isochorismatase domain containing 1	3
<a href="#">3838</a>	KPNA2	karyopherin subunit alpha 2	3
<a href="#">2553</a>	GABPB1	GA binding protein transcription factor beta subunit 1	3
<a href="#">57486</a>	NLN	neurolysin	3
<a href="#">10130</a>	PDIA6	protein disulfide isomerase family A member 6	3
<a href="#">65008</a>	MRPL1	mitochondrial ribosomal protein L1	3
<a href="#">133957</a>	CCDC127	coiled-coil domain containing 127	3
<a href="#">131474</a>	CHCHD4	coiled-coil-helix-coiled-coil-helix domain containing 4	3
<a href="#">65265</a>	C8orf33	chromosome 8 open reading frame 33	3
<a href="#">10440</a>	TIMM17A	translocase of inner mitochondrial membrane 17 homolog A (yeast)	3
<a href="#">27292</a>	DIMT1	DIM1 dimethyladenosine transferase 1 homolog	3
<a href="#">7336</a>	UBE2V2	ubiquitin conjugating enzyme E2 V2	3
<a href="#">80746</a>	TSEN2	tRNA splicing endonuclease subunit 2	3
<a href="#">8914</a>	TIMELESS	timeless circadian clock	3
<a href="#">2665</a>	GDI2	GDP dissociation inhibitor 2	3
<a href="#">83877</a>	TM2D2	TM2 domain containing 2	3
<a href="#">2618</a>	GART	phosphoribosylglycinamide formyltransferase, phosphoribosylglycinamide synthetase,	3
<a href="#">81034</a>	SLC25A32	phosphoribosylaminoimidazole synthetase	3
<a href="#">29088</a>	MRPL15	solute carrier family 25 member 32	3
<a href="#">56647</a>	BCCIP	mitochondrial ribosomal protein L15	3
<a href="#">10935</a>	PRDX3	BRCA2 and CDKN1A interacting protein	3
<a href="#">5464</a>	PPA1	peroxiredoxin 3	3
<a href="#">55226</a>	NAT10	pyrophosphatase (inorganic) 1	3
<a href="#">27349</a>	MCAT	N-acetyltransferase 10	3
<a href="#">11335</a>	CBX3	malonyl-CoA-acyl carrier protein transacylase	3
<a href="#">1267</a>	CNP	chromobox 3	3
<a href="#">28998</a>	MRPL13	2',3'-cyclic nucleotide 3' phosphodiesterase	3
<a href="#">6945</a>	MLX	mitochondrial ribosomal protein L13	3
<a href="#">23203</a>	PMPCA	MLX, MAX dimerization protein	3
<a href="#">4190</a>	MDH1	peptidase, mitochondrial processing alpha subunit	3
<a href="#">84790</a>	TUBA1C	malate dehydrogenase 1	3
<a href="#">54997</a>	TESC	tubulin alpha 1c	3
<a href="#">153443</a>	SRFBP1	tescalcin	3
<a href="#">55164</a>	SHQ1	serum response factor binding protein 1	3
<a href="#">8939</a>	FUBP3	SHQ1, H/ACA ribonucleoprotein assembly factor	3
		far upstream element binding protein 3	3

<a href="#">84991</a>	RBM17	RNA binding motif protein 17	3
<a href="#">26354</a>	GNL3	G protein nucleolar 3	3
<a href="#">84154</a>	RPF2	ribosome production factor 2 homolog	3
<a href="#">10946</a>	SF3A3	splicing factor 3a subunit 3	3
<a href="#">8727</a>	CTNNA1	catenin alpha like 1	3
<a href="#">100287932</a>	TIMM23	translocase of inner mitochondrial membrane 23	3
<a href="#">7027</a>	TFDP1	transcription factor Dp-1	3
<a href="#">55775</a>	TDP1	tyrosyl-DNA phosphodiesterase 1	3
<a href="#">4723</a>	NDUFB1	NADH:ubiquinone oxidoreductase core subunit V1	3
<a href="#">9352</a>	TXNL1	thioredoxin like 1	3
<a href="#">84541</a>	KBTBD8	kelch repeat and BTB domain containing 8	3
<a href="#">10563</a>	CXCL13	C-X-C motif chemokine ligand 13	3
<a href="#">5796</a>	PTPRK	protein tyrosine phosphatase, receptor type K	3
<a href="#">10940</a>	POP1	POP1 homolog, ribonuclease P/MRP subunit	3
<a href="#">9818</a>	NUP58	nucleoporin 58	3
<a href="#">8602</a>	NOP14	NOP14 nucleolar protein	3
		phosphoribosylaminoimidazole carboxylase;	
<a href="#">10606</a>	PAICS	phosphoribosylaminoimidazolesuccinocarboxamide synthase	3
<a href="#">10963</a>	STIP1	stress induced phosphoprotein 1	3
<a href="#">51018</a>	RRP15	ribosomal RNA processing 15 homolog	3
<a href="#">284098</a>	PIGW	phosphatidylinositol glycan anchor biosynthesis class W	3
<a href="#">8661</a>	EIF3A	eukaryotic translation initiation factor 3 subunit A	3
<a href="#">79731</a>	NARS2	asparaginyl-tRNA synthetase 2, mitochondrial (putative)	3
<a href="#">54806</a>	AHI1	Abelson helper integration site 1	3
<a href="#">55326</a>	AGPAT5	1-acylglycerol-3-phosphate O-acyltransferase 5	3
<a href="#">9277</a>	WDR46	WD repeat domain 46	3
<a href="#">34</a>	ACADM	acyl-CoA dehydrogenase, C-4 to C-12 straight chain	3
<a href="#">9933</a>	PUM3	pumilio RNA binding family member 3	3
<a href="#">3183</a>	HNRNPC	heterogeneous nuclear ribonucleoprotein C (C1/C2)	3
<a href="#">3609</a>	ILF3	interleukin enhancer binding factor 3	3
<a href="#">8847</a>	DLEU2	deleted in lymphocytic leukemia 2 (non-protein coding)	3
<a href="#">84444</a>	DOT1L	DOT1 like histone lysine methyltransferase	3
<a href="#">79728</a>	PALB2	partner and localizer of BRCA2	3
<a href="#">7675</a>	ZNF121	zinc finger protein 121	3
<a href="#">3190</a>	HNRNPK	heterogeneous nuclear ribonucleoprotein K	3
<a href="#">54928</a>	IMPAD1	inositol monophosphatase domain containing 1	3
<a href="#">55055</a>	ZWILCH	zwilch kinetochore protein	3
<a href="#">51649</a>	MRPS23	mitochondrial ribosomal protein S23	3
<a href="#">6432</a>	SRSF7	serine and arginine rich splicing factor 7	3
<a href="#">9689</a>	BZW1	basic leucine zipper and W2 domains 1	3
<a href="#">57122</a>	NUP107	nucleoporin 107	3
<a href="#">55839</a>	CENPN	centromere protein N	3
<a href="#">7337</a>	UBE3A	ubiquitin protein ligase E3A	3
<a href="#">7520</a>	XRCC5	X-ray repair cross complementing 5	3
<a href="#">29843</a>	SENP1	SUMO1/sentrin specific peptidase 1	3
<a href="#">5981</a>	RFC1	replication factor C subunit 1	3
<a href="#">87</a>	ACTN1	actinin alpha 1	3
<a href="#">92162</a>	TMEM88	transmembrane protein 88	3
<a href="#">10951</a>	CBX1	chromobox 1	3
<a href="#">2821</a>	GPI	glucose-6-phosphate isomerase	3
<a href="#">79931</a>	TNIP3	TNFAIP3 interacting protein 3	3
<a href="#">54512</a>	EXOSC4	exosome component 4	3
<a href="#">8682</a>	PEA15	phosphoprotein enriched in astrocytes 15	3
<a href="#">5033</a>	P4HA1	prolyl 4-hydroxylase subunit alpha 1	3
<a href="#">80762</a>	NDIFP1	Nedd4 family interacting protein 1	3
<a href="#">10262</a>	SF3B4	splicing factor 3b subunit 4	3
<a href="#">5230</a>	PGK1	phosphoglycerate kinase 1	3
<a href="#">7334</a>	UBE2N	ubiquitin conjugating enzyme E2 N	3
<a href="#">143279</a>	HECTD2	HECT domain E3 ubiquitin protein ligase 2	3
<a href="#">440093</a>	H3F3C	H3 histone family member 3C	3
<a href="#">760</a>	CA2	carbonic anhydrase 2	3
<a href="#">6621</a>	SNAPC4	small nuclear RNA activating complex polypeptide 4	3
<a href="#">4678</a>	NASP	nuclear autoantigenic sperm protein	3
<a href="#">339448</a>	C1orf174	chromosome 1 open reading frame 174	3
<a href="#">8099</a>	CDK2AP1	cyclin dependent kinase 2 associated protein 1	3

<a href="#">2968</a>	GTF2H4	general transcription factor IIH subunit 4	3
<a href="#">64928</a>	MRPL14	mitochondrial ribosomal protein L14	3
<a href="#">51651</a>	PTRH2	peptidyl-tRNA hydrolase 2	3
<a href="#">23583</a>	SMUG1	single-strand-selective monofunctional uracil-DNA glycosylase 1	3
<a href="#">7295</a>	TXN	thioredoxin	3
<a href="#">2017</a>	CTTN	cortactin	3
<a href="#">8493</a>	PPM1D	protein phosphatase, Mg <sup>2+</sup> /Mn <sup>2+</sup> dependent 1D	3
<a href="#">10813</a>	UTP14A	UTP14A small subunit processome component	3
<a href="#">84267</a>	C9orf64	chromosome 9 open reading frame 64	3
<a href="#">55276</a>	PGM2	phosphoglucomutase 2	3
<a href="#">54606</a>	DDX56	DEAD-box helicase 56	3
<a href="#">130367</a>	SGPP2	sphingosine-1-phosphate phosphatase 2	3
<a href="#">1317</a>	SLC31A1	solute carrier family 31 member 1	3
<a href="#">11333</a>	PDAP1	PDGFA associated protein 1	3
<a href="#">51020</a>	HDDC2	HD domain containing 2	3
<a href="#">23512</a>	SUZ12	SUZ12 polycomb repressive complex 2 subunit	3
<a href="#">9927</a>	MFN2	mitofusin 2	3
<a href="#">84365</a>	NIFK	nucleolar protein interacting with the FHA domain of MKI67	3
<a href="#">80742</a>	PRR3	proline rich 3	3
<a href="#">10557</a>	RPP38	ribonuclease P/MRP subunit p38	3
<a href="#">26589</a>	MRPL46	mitochondrial ribosomal protein L46	3
<a href="#">51491</a>	NOP16	NOP16 nucleolar protein	3
<a href="#">10899</a>	JTB	jumping translocation breakpoint	3
<a href="#">51218</a>	GLRX5	glutaredoxin 5	3
<a href="#">11331</a>	PHB2	prohibitin 2	3
<a href="#">10195</a>	ALG3	ALG3, alpha-1,3- mannosyltransferase	3
<a href="#">6503</a>	SLA	Src-like-adaptor	3
<a href="#">65993</a>	MRPS34	mitochondrial ribosomal protein S34	3
<a href="#">6364</a>	CCL20	C-C motif chemokine ligand 20	3
<a href="#">7551</a>	ZNF3	zinc finger protein 3	4
<a href="#">53405</a>	CLIC5	chloride intracellular channel 5	4
<a href="#">130589</a>	GALM	galactose mutarotase	4
<a href="#">8574</a>	AKR7A2	aldo-keto reductase family 7 member A2	4
<a href="#">29062</a>	WDR91	WD repeat domain 91	4
<a href="#">6051</a>	RNPEP	arginyl aminopeptidase	4
<a href="#">688</a>	KLF5	Kruppel like factor 5	4
<a href="#">10620</a>	ARID3B	AT-rich interaction domain 3B	4
<a href="#">144195</a>	SLC2A14	solute carrier family 2 member 14	4
<a href="#">10475</a>	TRIM38	tripartite motif containing 38	4
<a href="#">90529</a>	STPG1	sperm tail PG-rich repeat containing 1	4
<a href="#">6195</a>	RPS6KA1	ribosomal protein S6 kinase A1	4
<a href="#">864</a>	RUNX3	runt related transcription factor 3	4
<a href="#">10474</a>	TADA3	transcriptional adaptor 3	4
<a href="#">90589</a>	ZNF625	zinc finger protein 625	4
<a href="#">84941</a>	HSH2D	hematopoietic SH2 domain containing	4
<a href="#">127943</a>	FCRLB	Fc receptor like B	4
<a href="#">54894</a>	RNF43	ring finger protein 43	4
<a href="#">64121</a>	RRAGC	Ras related GTP binding C	4
<a href="#">347732</a>	CATSPER3	cation channel sperm associated 3	4
<a href="#">54914</a>	FOCAD	focadhesin	4
<a href="#">90488</a>	TMEM263	transmembrane protein 263	4
<a href="#">339201</a>	ASB16-AS1	ASB16 antisense RNA 1	4
<a href="#">4641</a>	MYO1C	myosin IC	4
<a href="#">92014</a>	SLC25A51	solute carrier family 25 member 51	4
<a href="#">5871</a>	MAP4K2	mitogen-activated protein kinase kinase kinase 2	4
<a href="#">27010</a>	TPK1	thiamin pyrophosphokinase 1	4
<a href="#">2043</a>	EPHA4	EPH receptor A4	4
<a href="#">4603</a>	MYBL1	MYB proto-oncogene like 1	4
<a href="#">83988</a>	NCALD	neurocalcin delta	4
<a href="#">79158</a>	GNPTAB	N-acetylglucosamine-1-phosphate transferase alpha and beta subunits	4
<a href="#">57646</a>	USP28	ubiquitin specific peptidase 28	4
<a href="#">23403</a>	FBXO46	F-box protein 46	4
<a href="#">11059</a>	WWP1	WW domain containing E3 ubiquitin protein ligase 1	4
<a href="#">7700</a>	ZNF141	zinc finger protein 141	4
<a href="#">5311</a>	PKD2	polycystin 2, transient receptor potential cation channel	4

<a href="#">79627</a>	OGFRL1	opioid growth factor receptor like 1	4
<a href="#">286827</a>	TRIM59	tripartite motif containing 59	4
<a href="#">10902</a>	BRD8	bromodomain containing 8	4
<a href="#">26269</a>	FBXO8	F-box protein 8	4
<a href="#">11153</a>	FICD	FIC domain containing	4
<a href="#">9846</a>	GAB2	GRB2 associated binding protein 2	4
<a href="#">57580</a>	PREX1	phosphatidylinositol-3,4,5-trisphosphate dependent Rac exchange factor 1	4
<a href="#">3248</a>	HPGD	hydroxyprostaglandin dehydrogenase 15-(NAD)	4
<a href="#">133308</a>	SLC9B2	solute carrier family 9 member B2	4
<a href="#">55650</a>	PIGV	phosphatidylinositol glycan anchor biosynthesis class V	4
<a href="#">168374</a>	ZNF92	zinc finger protein 92	4
<a href="#">115426</a>	UHRF2	ubiquitin like with PHD and ring finger domains 2	4
<a href="#">100133211</a>	LOC100133211	related RAS viral (r-ras) oncogene homolog 2 pseudogene	4
<a href="#">2800</a>	GOLGA1	golgin A1	4
<a href="#">22858</a>	ICK	intestinal cell kinase	4
<a href="#">64005</a>	MYO1G	myosin IG	4
<a href="#">54820</a>	NDE1	nudE neurodevelopment protein 1	4
<a href="#">81602</a>	CDADC1	cytidine and dCMP deaminase domain containing 1	4
<a href="#">920</a>	CD4	CD4 molecule	4
<a href="#">27013</a>	CNPPD1	cyclin Pas1/PHO80 domain containing 1	4
<a href="#">84440</a>	RAB11FIP4	RAB11 family interacting protein 4	4
<a href="#">9368</a>	SLC9A3R1	SLC9A3 regulator 1	4
<a href="#">4798</a>	NFRKB	nuclear factor related to kappaB binding protein	4
<a href="#">154141</a>	MBOAT1	membrane bound O-acyltransferase domain containing 1	4
<a href="#">5867</a>	RAB4A	RAB4A, member RAS oncogene family	4
<a href="#">54941</a>	RNF125	ring finger protein 125	4
<a href="#">100131827</a>	ZNF717	zinc finger protein 717	4
<a href="#">9814</a>	SFI1	SFI1 centrin binding protein	4
<a href="#">55758</a>	RCOR3	REST corepressor 3	4
<a href="#">149840</a>	C20orf196	chromosome 20 open reading frame 196	4
<a href="#">222068</a>	TMED4	transmembrane p24 trafficking protein 4	4
<a href="#">84993</a>	UBL7	ubiquitin like 7	4
<a href="#">57493</a>	HEG1	heart development protein with EGF like domains 1	4
<a href="#">652</a>	BMP4	bone morphogenetic protein 4	4
<a href="#">6448</a>	SGSH	N-sulfoglucosamine sulfohydrolase	4
<a href="#">5635</a>	PRPSAP1	phosphoribosyl pyrophosphate synthetase associated protein 1	4
<a href="#">340061</a>	TMEM173	transmembrane protein 173	4
<a href="#">51164</a>	DCTN4	dynactin subunit 4	4
<a href="#">83986</a>	FAM234A	family with sequence similarity 234 member A	4
<a href="#">440515</a>	ZNF506	zinc finger protein 506	4
<a href="#">2185</a>	PTK2B	protein tyrosine kinase 2 beta	4
<a href="#">9159</a>	PCSK7	proprotein convertase subtilisin/kexin type 7	4
<a href="#">148137</a>	PROSER3	proline and serine rich 3	4
<a href="#">84196</a>	USP48	ubiquitin specific peptidase 48	4
<a href="#">2909</a>	ARHGAP35	Rho GTPase activating protein 35	4
<a href="#">10194</a>	TSHZ1	teashirt zinc finger homeobox 1	4
<a href="#">6482</a>	ST3GAL1	ST3 beta-galactoside alpha-2,3-sialyltransferase 1	4
<a href="#">165918</a>	RNF168	ring finger protein 168	4
<a href="#">1027</a>	CDKN1B	cyclin dependent kinase inhibitor 1B	4
<a href="#">162962</a>	ZNF836	zinc finger protein 836	4
<a href="#">90233</a>	ZNF551	zinc finger protein 551	4
<a href="#">58986</a>	TMEM8A	transmembrane protein 8A	4
<a href="#">80017</a>	C14orf159	chromosome 14 open reading frame 159	4
<a href="#">8707</a>	B3GALT2	beta-1,3-galactosyltransferase 2	4
<a href="#">8717</a>	TRADD	TNFRSF1A associated via death domain	4
<a href="#">6293</a>	VPS52	VPS52, GARP complex subunit	4
<a href="#">54843</a>	SYTL2	synaptotagmin like 2	4
<a href="#">4126</a>	MANBA	mannosidase beta	4
<a href="#">57589</a>	RIC1	RIC1 homolog, RAB6A GEF complex partner 1	4
<a href="#">23233</a>	EXOC6B	exocyst complex component 6B	4
<a href="#">22898</a>	DENND3	DENN domain containing 3	4
<a href="#">157638</a>	FAM84B	family with sequence similarity 84 member B	4
<a href="#">4644</a>	MYO5A	myosin VA	4
<a href="#">51684</a>	SUFU	SUFU negative regulator of hedgehog signaling	4
<a href="#">3956</a>	LGALS1	galectin 1	4



<a href="#">100506334</a>	LINC00649	long intergenic non-protein coding RNA 649	4
<a href="#">128338</a>	DRAM2	DNA damage regulated autophagy modulator 2	4
<a href="#">283349</a>	RASSF3	Ras association domain family member 3	4
<a href="#">222255</a>	ATXN7L1	ataxin 7 like 1	4
<a href="#">409</a>	ARRB2	arrestin beta 2	4
<a href="#">9674</a>	KIAA0040	KIAA0040	4
<a href="#">7360</a>	UGP2	UDP-glucose pyrophosphorylase 2	4
<a href="#">51246</a>	SHISA5	shisa family member 5	4
<a href="#">9985</a>	REC8	REC8 meiotic recombination protein	4
<a href="#">283130</a>	SLC25A45	solute carrier family 25 member 45	4
<a href="#">59339</a>	PLEKHA2	pleckstrin homology domain containing A2	4
<a href="#">10577</a>	NPC2	NPC intracellular cholesterol transporter 2	4
<a href="#">3120</a>	HLA-DQB2	major histocompatibility complex, class II, DQ beta 2	4
<a href="#">54870</a>	QRICH1	glutamine rich 1	4
<a href="#">78991</a>	PCYOX1L	prenylcysteine oxidase 1 like	4
<a href="#">64863</a>	METTL4	methyltransferase like 4	4
<a href="#">4240</a>	MFGE8	milk fat globule-EGF factor 8 protein	4
<a href="#">51439</a>	FAM8A1	family with sequence similarity 8 member A1	4
<a href="#">10140</a>	TOB1	transducer of ERBB2, 1	4
<a href="#">23484</a>	LEPROTL1	leptin receptor overlapping transcript-like 1	4
<a href="#">51292</a>	GMPR2	guanosine monophosphate reductase 2	4
<a href="#">120224</a>	TMEM45B	transmembrane protein 45B	4
<a href="#">9337</a>	CNOT8	CCR4-NOT transcription complex subunit 8	4
<a href="#">23582</a>	CCNDBP1	cyclin D1 binding protein 1	4
<a href="#">284309</a>	ZNF776	zinc finger protein 776	4
<a href="#">8440</a>	NCK2	NCK adaptor protein 2	4
<a href="#">10581</a>	IFITM2	interferon induced transmembrane protein 2	4
<a href="#">51390</a>	AIG1	androgen induced 1	4
<a href="#">56477</a>	CCL28	C-C motif chemokine ligand 28	4
<a href="#">201627</a>	DENND6A	DENN domain containing 6A	4
<a href="#">101</a>	ADAM8	ADAM metallopeptidase domain 8	4
<a href="#">10311</a>	DSCR3	DSCR3 arrestin fold containing	4
<a href="#">156</a>	GRK2	G protein-coupled receptor kinase 2	4
<a href="#">55339</a>	WDR33	WD repeat domain 33	4
<a href="#">90736</a>	FAM104B	family with sequence similarity 104 member B	4
<a href="#">64857</a>	PLEKHG2	pleckstrin homology and RhoGEF domain containing G2	4
<a href="#">54813</a>	KLHL28	kelch like family member 28	4
<a href="#">140461</a>	ASB8	ankyrin repeat and SOCS box containing 8	4
<a href="#">81846</a>	SBF2	SET binding factor 2	4
<a href="#">25943</a>	C20orf194	chromosome 20 open reading frame 194	4
<a href="#">54868</a>	TMEM104	transmembrane protein 104	4
<a href="#">23171</a>	GPD1L	glycerol-3-phosphate dehydrogenase 1-like	4
<a href="#">2745</a>	GLRX	glutaredoxin	4
<a href="#">54970</a>	TTC12	tetratricopeptide repeat domain 12	4
<a href="#">84614</a>	ZBTB37	zinc finger and BTB domain containing 37	4
<a href="#">828</a>	CAPS	calcyphosine	4
<a href="#">1659</a>	DHX8	DEAH-box helicase 8	4
<a href="#">147694</a>	ZNF548	zinc finger protein 548	4
<a href="#">26036</a>	ZNF451	zinc finger protein 451	4
<a href="#">285550</a>	FAM200B	family with sequence similarity 200 member B	4
<a href="#">147658</a>	ZNF534	zinc finger protein 534	4
<a href="#">147923</a>	ZNF420	zinc finger protein 420	4
<a href="#">7536</a>	SF1	splicing factor 1	4
<a href="#">285596</a>	FAM153A	family with sequence similarity 153 member A	4
<a href="#">57452</a>	GALNT16	polypeptide N-acetylgalactosaminyltransferase 16	4
<a href="#">56339</a>	METTL3	methyltransferase like 3	4
<a href="#">100129842</a>	ZNF737	zinc finger protein 737	4
<a href="#">124460</a>	SNX20	sorting nexin 20	4
<a href="#">51696</a>	HECA	hdc homolog, cell cycle regulator	4
<a href="#">6811</a>	STX5	syntaxin 5	4
<a href="#">51643</a>	TMBIM4	transmembrane BAX inhibitor motif containing 4	4
<a href="#">388650</a>	FAM69A	family with sequence similarity 69 member A	4
<a href="#">8027</a>	STAM	signal transducing adaptor molecule	4
<a href="#">4850</a>	CNOT4	CCR4-NOT transcription complex subunit 4	4
<a href="#">4676</a>	NAP1L4	nucleosome assembly protein 1 like 4	4

<a href="#">7690</a>	ZNF131	zinc finger protein 131	4
<a href="#">6789</a>	STK4	serine/threonine kinase 4	4
<a href="#">55634</a>	KRBOX4	KRAB box domain containing 4	4
<a href="#">63897</a>	HEATR6	HEAT repeat containing 6	4
<a href="#">1374</a>	CPT1A	carnitine palmitoyltransferase 1A	4
<a href="#">6402</a>	SELL	selectin L	4
<a href="#">7592</a>	ZNF41	zinc finger protein 41	4
<a href="#">372</a>	ARCN1	archain 1	4
<a href="#">23451</a>	SF3B1	splicing factor 3b subunit 1	4
<a href="#">163081</a>	ZNF567	zinc finger protein 567	4
<a href="#">7381</a>	UQCRB	ubiquinol-cytochrome c reductase binding protein	4
<a href="#">6230</a>	RPS25	ribosomal protein S25	4
<a href="#">83452</a>	RAB33B	RAB33B, member RAS oncogene family	4
<a href="#">56987</a>	BBX	BBX, HMG-box containing	4
<a href="#">9541</a>	CIR1	corepressor interacting with RBPJ, 1	4
<a href="#">9534</a>	ZNF254	zinc finger protein 254	4
<a href="#">54986</a>	ULK4	unc-51 like kinase 4	4
<a href="#">64421</a>	DCLRE1C	DNA cross-link repair 1C	4
<a href="#">51531</a>	TRMO	tRNA methyltransferase O	4
<a href="#">114781</a>	BTBD9	BTB domain containing 9	4
<a href="#">5150</a>	PDE7A	phosphodiesterase 7A	4
<a href="#">55729</a>	ATF7IP	activating transcription factor 7 interacting protein	4
<a href="#">285343</a>	TCAIM	T-cell activation inhibitor, mitochondrial	4
<a href="#">6671</a>	SP4	Sp4 transcription factor	4
<a href="#">9252</a>	RPS6KA5	ribosomal protein S6 kinase A5	4
<a href="#">64940</a>	STAG3L4	stromal antigen 3-like 4 (pseudogene)	4
<a href="#">10681</a>	GNB5	G protein subunit beta 5	4
<a href="#">3845</a>	KRAS	KRAS proto-oncogene, GTPase	4
<a href="#">54542</a>	RC3H2	ring finger and CCCH-type domains 2	4
<a href="#">961</a>	CD47	CD47 molecule	4
<a href="#">84084</a>	RAB6C	RAB6C, member RAS oncogene family	4
<a href="#">22883</a>	CLSTN1	calsyntenin 1	4
<a href="#">3385</a>	ICAM3	intercellular adhesion molecule 3	4
<a href="#">57533</a>	TBC1D14	TBC1 domain family member 14	4
<a href="#">375743</a>	PTAR1	protein prenyltransferase alpha subunit repeat containing 1	4
<a href="#">3738</a>	KCNA3	potassium voltage-gated channel subfamily A member 3	4
<a href="#">9697</a>	TRAM2	translocation associated membrane protein 2	4
<a href="#">55296</a>	TBC1D19	TBC1 domain family member 19	4
<a href="#">9873</a>	FCHSD2	FCH and double SH3 domains 2	4
<a href="#">105371242</a>	LOC105371242	peptidyl-prolyl cis-trans isomerase A-like 4C	4
<a href="#">643836</a>	ZFP62	ZFP62 zinc finger protein	4
<a href="#">23161</a>	SNX13	sorting nexin 13	4
<a href="#">9197</a>	SLC33A1	solute carrier family 33 member 1	4
<a href="#">1955</a>	MEGF9	multiple EGF like domains 9	4
<a href="#">57198</a>	ATP8B2	ATPase phospholipid transporting 8B2	4
<a href="#">105372141</a>	LOC105372141	uncharacterized LOC105372141	4
<a href="#">9798</a>	IST1	IST1, ESCRT-III associated factor	4
<a href="#">54521</a>	WDR44	WD repeat domain 44	4
<a href="#">57534</a>	MIB1	mindbomb E3 ubiquitin protein ligase 1	4
<a href="#">84124</a>	ZNF394	zinc finger protein 394	4
<a href="#">25852</a>	ARMC8	armadillo repeat containing 8	4
<a href="#">54739</a>	XAF1	XIAP associated factor 1	4
<a href="#">8869</a>	ST3GAL5	ST3 beta-galactoside alpha-2,3-sialyltransferase 5	4
<a href="#">5027</a>	P2RX7	purinergic receptor P2X 7	4
<a href="#">51</a>	ACOX1	acyl-CoA oxidase 1	4
<a href="#">9482</a>	STX8	syntaxin 8	4
<a href="#">84079</a>	ANKRD27	ankyrin repeat domain 27	4
<a href="#">10855</a>	HPSE	heparanase	4
<a href="#">23097</a>	CDK19	cyclin dependent kinase 19	4
<a href="#">54149</a>	C21orf91	chromosome 21 open reading frame 91	4
<a href="#">9258</a>	MFHAS1	malignant fibrous histiocytoma amplified sequence 1	4
<a href="#">5613</a>	PRKX	protein kinase, X-linked	4
<a href="#">8237</a>	USP11	ubiquitin specific peptidase 11	4
<a href="#">134553</a>	C5orf24	chromosome 5 open reading frame 24	4
<a href="#">9913</a>	SUPT7L	SPT7-like STAGA complex gamma subunit	4

<a href="#">64077</a>	LHPP	phospholysine phosphohistidine inorganic pyrophosphate phosphatase	4
<a href="#">28232</a>	SLCO3A1	solute carrier organic anion transporter family member 3A1	4
<a href="#">51606</a>	ATP6V1H	ATPase H+ transporting V1 subunit H	4
<a href="#">83541</a>	FAM110A	family with sequence similarity 110 member A	4
<a href="#">146857</a>	SLFN13	schlafen family member 13	4
<a href="#">136895</a>	C7orf31	chromosome 7 open reading frame 31	4
<a href="#">360023</a>	ZBTB41	zinc finger and BTB domain containing 41	4
<a href="#">56985</a>	ADPRM	ADP-ribose/CDP-alcohol diphosphatase, manganese dependent	4
<a href="#">92799</a>	SHKBP1	SH3KBP1 binding protein 1	4
<a href="#">23199</a>	GSE1	Gse1 coiled-coil protein	4
<a href="#">259197</a>	NCR3	natural cytotoxicity triggering receptor 3	4
<a href="#">10299</a>	MARCH6	membrane associated ring-CH-type finger 6	4
<a href="#">1757</a>	SARDH	sarcosine dehydrogenase	4
<a href="#">27005</a>	USP21	ubiquitin specific peptidase 21	4
<a href="#">51244</a>	CCDC174	coiled-coil domain containing 174	4
<a href="#">8573</a>	CASK	calcium/calmodulin dependent serine protein kinase	4
<a href="#">8603</a>	FAM193A	family with sequence similarity 193 member A	4
<a href="#">26043</a>	UBXN7	UBX domain protein 7	4
<a href="#">57105</a>	CYSLTR2	cysteinyl leukotriene receptor 2	4
<a href="#">55180</a>	LINS1	lines homolog 1	4
<a href="#">153642</a>	ARSK	arylsulfatase family member K	4
<a href="#">91663</a>	MYADM	myeloid associated differentiation marker	4
<a href="#">23131</a>	GPATCH8	G-patch domain containing 8	4
<a href="#">11143</a>	KAT7	lysine acetyltransferase 7	4
<a href="#">23259</a>	DDHD2	DDHD domain containing 2	4
<a href="#">148268</a>	ZNF570	zinc finger protein 570	4
<a href="#">50809</a>	HP1BP3	heterochromatin protein 1 binding protein 3	4
<a href="#">9991</a>	PTBP3	polypyrimidine tract binding protein 3	4
<a href="#">285513</a>	GPRIN3	GPRIN family member 3	4
<a href="#">1859</a>	DYRK1A	dual specificity tyrosine phosphorylation regulated kinase 1A	4
<a href="#">10513</a>	APBP2	amyloid beta precursor protein binding protein 2	4
<a href="#">27252</a>	KLHL20	kelch like family member 20	4
<a href="#">374354</a>	NHLRC2	NHL repeat containing 2	4
<a href="#">7159</a>	TP53BP2	tumor protein p53 binding protein 2	4
<a href="#">27018</a>	BEX3	brain expressed X-linked 3	4
<a href="#">7433</a>	VIPR1	vasoactive intestinal peptide receptor 1	4
<a href="#">9946</a>	CRYZL1	crystallin zeta like 1	4
<a href="#">23229</a>	ARHGEF9	Cdc42 guanine nucleotide exchange factor 9	4
<a href="#">286336</a>	FAM78A	family with sequence similarity 78 member A	4
<a href="#">6809</a>	STX3	syntaxin 3	4
<a href="#">8776</a>	MTMR1	myotubularin related protein 1	4
<a href="#">8545</a>	CGGBP1	CGG triplet repeat binding protein 1	4
<a href="#">26136</a>	TES	testin LIM domain protein	4
<a href="#">93594</a>	TBC1D31	TBC1 domain family member 31	4
<a href="#">51281</a>	ANKMY1	ankyrin repeat and MYND domain containing 1	4
<a href="#">58486</a>	ZBED5	zinc finger BED-type containing 5	4
<a href="#">4253</a>	MIA2	melanoma inhibitory activity 2	4
<a href="#">4170</a>	MCL1	BCL2 family apoptosis regulator	4
<a href="#">2272</a>	FHIT	fragile histidine triad	4
<a href="#">10866</a>	HCP5	HLA complex P5 (non-protein coding)	4
<a href="#">57396</a>	CLK4	CDC like kinase 4	4
<a href="#">171425</a>	CLYBL	citrate lyase beta like	4
<a href="#">7248</a>	TSC1	tuberous sclerosis 1	4
<a href="#">129685</a>	TAF8	TATA-box binding protein associated factor 8	4
<a href="#">22920</a>	KIFAP3	kinesin associated protein 3	4
<a href="#">159091</a>	FAM122C	family with sequence similarity 122C	4
<a href="#">25957</a>	PNISR	PNN interacting serine and arginine rich protein	4
<a href="#">91300</a>	R3HDM4	R3H domain containing 4	4
<a href="#">51427</a>	ZNF107	zinc finger protein 107	4
<a href="#">168850</a>	ZNF800	zinc finger protein 800	4
<a href="#">2273</a>	FHL1	four and a half LIM domains 1	4
<a href="#">10392</a>	NOD1	nucleotide binding oligomerization domain containing 1	4
<a href="#">1656</a>	DDX6	DEAD-box helicase 6	4
<a href="#">3991</a>	LIPE	lipase E, hormone sensitive type	4
<a href="#">91949</a>	COG7	component of oligomeric golgi complex 7	4

<a href="#">57120</a>	GOPC	golgi associated PDZ and coiled-coil motif containing	4
<a href="#">84911</a>	ZNF382	zinc finger protein 382	4
<a href="#">125488</a>	TTC39C	tetratricopeptide repeat domain 39C	4
<a href="#">51752</a>	ERAP1	endoplasmic reticulum aminopeptidase 1	4
<a href="#">222236</a>	NAPEPLD	N-acyl phosphatidylethanolamine phospholipase D	4
<a href="#">54331</a>	GNG2	G protein subunit gamma 2	4
<a href="#">23248</a>	RPRD2	regulation of nuclear pre-mRNA domain containing 2	4
<a href="#">4940</a>	OAS3	2'-5'-oligoadenylate synthetase 3	4
<a href="#">2011</a>	MARK2	microtubule affinity regulating kinase 2	4
<a href="#">56882</a>	CDC42SE1	CDC42 small effector 1	4
<a href="#">23635</a>	SSBP2	single stranded DNA binding protein 2	4
<a href="#">4149</a>	MAX	MYC associated factor X	4
<a href="#">51199</a>	NIN	ninein	4
<a href="#">285195</a>	SLC9A9	solute carrier family 9 member A9	4
<a href="#">8473</a>	OGT	O-linked N-acetylglucosamine (GlcNAc) transferase	4
<a href="#">285440</a>	CYP4V2	cytochrome P450 family 4 subfamily V member 2	4
<a href="#">9709</a>	HERPUD1	homocysteine inducible ER protein with ubiquitin like domain 1	4
<a href="#">54816</a>	ZNF280D	zinc finger protein 280D	4
<a href="#">26578</a>	OSTF1	osteoclast stimulating factor 1	4
<a href="#">6815</a>	STYX	serine/threonine/tyrosine interacting protein	4
<a href="#">663</a>	BNIP2	BCL2 interacting protein 2	4
<a href="#">9779</a>	TBC1D5	TBC1 domain family member 5	4
<a href="#">55773</a>	TBC1D23	TBC1 domain family member 23	4
<a href="#">57185</a>	NIPAL3	NIPA like domain containing 3	4
<a href="#">23204</a>	ARL6IP1	ADP ribosylation factor like GTPase 6 interacting protein 1	4
<a href="#">8773</a>	SNAP23	synaptosome associated protein 23	4
<a href="#">6303</a>	SAT1	spermidine/spermine N1-acetyltransferase 1	4
<a href="#">57560</a>	IFT80	intraflagellar transport 80	4
<a href="#">2948</a>	GSTM4	glutathione S-transferase mu 4	4
<a href="#">3115</a>	HLA-DPB1	major histocompatibility complex, class II, DP beta 1	4
<a href="#">79668</a>	PARP8	poly(ADP-ribose) polymerase family member 8	4
<a href="#">4707</a>	NDUFB1	NADH:ubiquinone oxidoreductase subunit B1	4
<a href="#">22901</a>	ARSG	arylsulfatase G	4
<a href="#">84343</a>	HPS3	HPS3, biogenesis of lysosomal organelles complex 2 subunit 1	4
<a href="#">54407</a>	SLC38A2	solute carrier family 38 member 2	4
<a href="#">50999</a>	TMED5	transmembrane p24 trafficking protein 5	4
<a href="#">3958</a>	LGALS3	galectin 3	4
<a href="#">64840</a>	PORCN	porcupine homolog (Drosophila)	4
<a href="#">5562</a>	PRKAA1	protein kinase AMP-activated catalytic subunit alpha 1	4
<a href="#">9039</a>	UBA3	ubiquitin like modifier activating enzyme 3	4
<a href="#">57649</a>	PHF12	PHD finger protein 12	4
<a href="#">90806</a>	ANGEL2	angel homolog 2	4
<a href="#">7581</a>	ZNF33A	zinc finger protein 33A	4
<a href="#">375248</a>	ANKRD36	ankyrin repeat domain 36	4
<a href="#">8821</a>	INPP4B	inositol polyphosphate-4-phosphatase type II B	4
<a href="#">23613</a>	ZMYND8	zinc finger MYND-type containing 8	4
<a href="#">567</a>	B2M	beta-2-microglobulin	4
<a href="#">9666</a>	DZIP3	DAZ interacting zinc finger protein 3	4
<a href="#">3459</a>	IFNGR1	interferon gamma receptor 1	4
<a href="#">55285</a>	RBM41	RNA binding motif protein 41	4
<a href="#">201895</a>	SMIM14	small integral membrane protein 14	4
<a href="#">29058</a>	TMEM230	transmembrane protein 230	4
<a href="#">9958</a>	USP15	ubiquitin specific peptidase 15	4
<a href="#">917</a>	CD3G	CD3g molecule	4
<a href="#">10181</a>	RBM5	RNA binding motif protein 5	4
<a href="#">55788</a>	LMBRD1	LMBR1 domain containing 1	4
<a href="#">6814</a>	STXBP3	syntaxin binding protein 3	4
<a href="#">1666</a>	DECR1	2,4-dienoyl-CoA reductase 1, mitochondrial	4
<a href="#">51506</a>	UFC1	ubiquitin-fold modifier conjugating enzyme 1	4
<a href="#">6281</a>	S100A10	S100 calcium binding protein A10	4
<a href="#">28962</a>	OSTM1	osteopetrosis associated transmembrane protein 1	4
<a href="#">54677</a>	CROT	carnitine O-octanoyltransferase	4
<a href="#">8799</a>	PEX11B	peroxisomal biogenesis factor 11 beta	4
<a href="#">1730</a>	DIAPH2	diaphanous related formin 2	4
<a href="#">9694</a>	EMC2	ER membrane protein complex subunit 2	4

<a href="#">7181</a>	NR2C1	nuclear receptor subfamily 2 group C member 1	4
<a href="#">51108</a>	METTL9	methyltransferase like 9	4
<a href="#">27141</a>	CIDEB	cell death-inducing DFFA-like effector b	4
<a href="#">64376</a>	IKZF5	IKAROS family zinc finger 5	4
<a href="#">7756</a>	ZNF207	zinc finger protein 207	4
<a href="#">256471</a>	MFSD8	major facilitator superfamily domain containing 8	4
<a href="#">3660</a>	IRF2	interferon regulatory factor 2	4
<a href="#">64431</a>	ACTR6	ARF6 actin-related protein 6 homolog	4
<a href="#">79872</a>	CBLL1	Cbl proto-oncogene like 1	4
<a href="#">337976</a>	KRTAP20-2	keratin associated protein 20-2	4
<a href="#">51347</a>	TAOK3	TAO kinase 3	4
<a href="#">1998</a>	ELF2	E74 like ETS transcription factor 2	4
<a href="#">84236</a>	RHBDD1	rhomboid domain containing 1	4
<a href="#">89978</a>	DPH6	diphthamine biosynthesis 6	4
<a href="#">8767</a>	RIPK2	receptor interacting serine/threonine kinase 2	4
<a href="#">79096</a>	C11orf49	chromosome 11 open reading frame 49	4
<a href="#">5930</a>	RBBP6	RB binding protein 6, ubiquitin ligase	4
<a href="#">645142</a>	PPIAL4D	peptidylprolyl isomerase A like 4D	4
<a href="#">148867</a>	SLC30A7	solute carrier family 30 member 7	4
<a href="#">145389</a>	SLC38A6	solute carrier family 38 member 6	4
<a href="#">26115</a>	TANC2	tetratricopeptide repeat, ankyrin repeat and coiled-coil containing 2	4
<a href="#">26515</a>	TIMM10B	translocase of inner mitochondrial membrane 10 homolog B (yeast)	4
<a href="#">10491</a>	CRTAP	cartilage associated protein	4
<a href="#">962</a>	CD48	CD48 molecule	4
<a href="#">3128</a>	HLA-DRB6	major histocompatibility complex, class II, DR beta 6 (pseudogene)	4
<a href="#">84333</a>	PCGF5	polycomb group ring finger 5	4
<a href="#">6301</a>	SARS	seryl-tRNA synthetase	4
<a href="#">148362</a>	BROX	BRO1 domain and CAAX motif containing	4
<a href="#">51322</a>	WAC	WW domain containing adaptor with coiled-coil	4
<a href="#">2060</a>	EPS15	epidermal growth factor receptor pathway substrate 15	4
<a href="#">64747</a>	MFSD1	major facilitator superfamily domain containing 1	4
<a href="#">79745</a>	CLIP4	CAP-Gly domain containing linker protein family member 4	4
<a href="#">84272</a>	YIPF4	Yip1 domain family member 4	4
<a href="#">3163</a>	HMOX2	heme oxygenase 2	4
<a href="#">1521</a>	CTSW	cathepsin W	4
<a href="#">85025</a>	TMEM60	transmembrane protein 60	4
<a href="#">56674</a>	TMEM9B	TMEM9 domain family member B	4
<a href="#">3384</a>	ICAM2	intercellular adhesion molecule 2	4
<a href="#">26061</a>	HACL1	2-hydroxyacyl-CoA lyase 1	4
<a href="#">27065</a>	NSG1	neuron specific gene family member 1	4
<a href="#">29994</a>	BAZ2B	bromodomain adjacent to zinc finger domain 2B	4
<a href="#">6643</a>	SNX2	sorting nexin 2	4
<a href="#">27240</a>	SIT1	signaling threshold regulating transmembrane adaptor 1	4
<a href="#">3117</a>	HLA-DQA1	major histocompatibility complex, class II, DQ alpha 1	4
<a href="#">27163</a>	NAAA	N-acylethanolamine acid amidase	4
<a href="#">84795</a>	PYROXD2	pyridine nucleotide-disulphide oxidoreductase domain 2	4
<a href="#">8667</a>	EIF3H	eukaryotic translation initiation factor 3 subunit H	4
<a href="#">254887</a>	ZDHHC23	zinc finger DHHC-type containing 23	4
<a href="#">124961</a>	ZFP3	ZFP3 zinc finger protein	4
<a href="#">26071</a>	FAM127B	family with sequence similarity 127 member B	4
<a href="#">23149</a>	FCHO1	FCH domain only 1	4
<a href="#">374395</a>	TMEM179B	transmembrane protein 179B	4
<a href="#">3688</a>	ITGB1	integrin subunit beta 1	4
<a href="#">4711</a>	NDUFB5	NADH:ubiquinone oxidoreductase subunit B5	4
<a href="#">9871</a>	SEC24D	SEC24 homolog D, COPII coat complex component	4
<a href="#">56898</a>	BDH2	3-hydroxybutyrate dehydrogenase, type 2	4
<a href="#">23585</a>	TMEM50A	transmembrane protein 50A	4
<a href="#">3133</a>	HLA-E	major histocompatibility complex, class I, E	4
<a href="#">124512</a>	METTL23	methyltransferase like 23	4
<a href="#">11000</a>	SLC27A3	solute carrier family 27 member 3	4
<a href="#">126626</a>	GABPB2	GA binding protein transcription factor beta subunit 2	4
<a href="#">257160</a>	RNF214	ring finger protein 214	4
<a href="#">9649</a>	RALGPS1	Ral GEF with PH domain and SH3 binding motif 1	4
<a href="#">26273</a>	FBXO3	F-box protein 3	4
<a href="#">54509</a>	RHOF	ras homolog family member F, filopodia associated	4

<a href="#">285093</a>	RTP5	receptor transporter protein 5 (putative)	4
<a href="#">25793</a>	FBX07	F-box protein 7	4
<a href="#">7770</a>	ZNF227	zinc finger protein 227	4
<a href="#">85403</a>	EAF1	ELL associated factor 1	4
<a href="#">4582</a>	MUC1	mucin 1, cell surface associated	4
<a href="#">1029</a>	CDKN2A	cyclin dependent kinase inhibitor 2A	4
<a href="#">3717</a>	JAK2	Janus kinase 2	4
<a href="#">1992</a>	SERPINB1	serpin family B member 1	4
<a href="#">25821</a>	MTO1	mitochondrial tRNA translation optimization 1	4
<a href="#">51635</a>	DHRS7	dehydrogenase/reductase 7	4
<a href="#">51747</a>	LUC7L3	LUC7 like 3 pre-mRNA splicing factor	4
<a href="#">10628</a>	TXNIP	thioredoxin interacting protein	4
<a href="#">5533</a>	PPP3CC	protein phosphatase 3 catalytic subunit gamma	4
<a href="#">5130</a>	PCYT1A	phosphate cytidyltransferase 1, choline, alpha	4
<a href="#">10219</a>	KLRG1	killer cell lectin like receptor G1	4
<a href="#">3127</a>	HLA-DRB5	major histocompatibility complex, class II, DR beta 5	4
<a href="#">253461</a>	ZBTB38	zinc finger and BTB domain containing 38	4
<a href="#">80267</a>	EDEM3	ER degradation enhancing alpha-mannosidase like protein 3	4
<a href="#">149628</a>	PYHIN1	pyrin and HIN domain family member 1	4
<a href="#">55508</a>	SLC35E3	solute carrier family 35 member E3	4
<a href="#">89853</a>	MVB12B	multivesicular body subunit 12B	4
<a href="#">2313</a>	FLI1	Fli-1 proto-oncogene, ETS transcription factor	4
<a href="#">79591</a>	C10orf76	chromosome 10 open reading frame 76	4
<a href="#">9204</a>	ZMYM6	zinc finger MYM-type containing 6	4
<a href="#">25975</a>	EGFL6	EGF like domain multiple 6	4
<a href="#">10039</a>	PARP3	poly(ADP-ribose) polymerase family member 3	4
<a href="#">54855</a>	FAM46C	family with sequence similarity 46 member C	4
<a href="#">171586</a>	ABHD3	abhydrolase domain containing 3	4
<a href="#">55809</a>	TRERF1	transcriptional regulating factor 1	4
<a href="#">115825</a>	WDFY2	WD repeat and FYVE domain containing 2	4
<a href="#">23059</a>	CLUAP1	clusterin associated protein 1	4
<a href="#">79877</a>	DCAKD	dephospho-CoA kinase domain containing	4
<a href="#">84273</a>	NOA1	nitric oxide associated 1	4
<a href="#">4835</a>	NQO2	NAD(P)H quinone dehydrogenase 2	4
<a href="#">283237</a>	TTC9C	tetratricopeptide repeat domain 9C	4
<a href="#">5797</a>	PTPRM	protein tyrosine phosphatase, receptor type M	4
<a href="#">3820</a>	KLRB1	killer cell lectin like receptor B1	4
<a href="#">4217</a>	MAP3K5	mitogen-activated protein kinase kinase kinase 5	4
<a href="#">64773</a>	PCED1A	PC-esterase domain containing 1A	4
<a href="#">2054</a>	STX2	syntaxin 2	4
<a href="#">824</a>	CAPN2	calpain 2	4
<a href="#">79577</a>	CDC73	cell division cycle 73	4
<a href="#">3108</a>	HLA-DMA	major histocompatibility complex, class II, DM alpha	4
<a href="#">154075</a>	SAMD3	sterile alpha motif domain containing 3	4
<a href="#">7905</a>	REEP5	receptor accessory protein 5	4
<a href="#">199704</a>	ZNF585A	zinc finger protein 585A	4
<a href="#">88455</a>	ANKRD13A	ankyrin repeat domain 13A	4
<a href="#">6668</a>	SP2	Sp2 transcription factor	4
<a href="#">1604</a>	CD55	CD55 molecule (Cromer blood group)	4
<a href="#">64420</a>	SUSD1	sushi domain containing 1	4
<a href="#">1235</a>	CCR6	C-C motif chemokine receptor 6	4
<a href="#">2838</a>	GPR15	G protein-coupled receptor 15	4
<a href="#">440026</a>	TMEM41B	transmembrane protein 41B	4
<a href="#">729230</a>	CCR2	C-C motif chemokine receptor 2	4
<a href="#">94101</a>	ORMDL1	ORMDL sphingolipid biosynthesis regulator 1	4
<a href="#">1075</a>	CTSC	cathepsin C	4
<a href="#">90624</a>	LYRM7	LYR motif containing 7	4
<a href="#">801</a>	CALM1	calmodulin 1	4
<a href="#">55967</a>	NDUFA12	NADH:ubiquinone oxidoreductase subunit A12	4
<a href="#">8477</a>	GPR65	G protein-coupled receptor 65	4
<a href="#">57544</a>	TXNDC16	thioredoxin domain containing 16	4
<a href="#">1512</a>	CTSH	cathepsin H	4
<a href="#">84902</a>	CEP89	centrosomal protein 89	4
<a href="#">7576</a>	ZNF28	zinc finger protein 28	4
<a href="#">29116</a>	MYLIP	myosin regulatory light chain interacting protein	4

<a href="#">50808</a>	AK3	adenylate kinase 3	4
<a href="#">7289</a>	TULP3	tubby like protein 3	4
<a href="#">6166</a>	RPL36AL	ribosomal protein L36a like	4
<a href="#">54414</a>	SIAE	sialic acid acetyltransferase	4
<a href="#">23673</a>	STX12	syntaxin 12	4
<a href="#">833</a>	CARS	cysteinyl-tRNA synthetase	4
<a href="#">7940</a>	LST1	leukocyte specific transcript 1	4
<a href="#">2040</a>	STOM	stomatin	4
<a href="#">5720</a>	PSME1	proteasome activator subunit 1	4
<a href="#">51101</a>	ZC2HC1A	zinc finger C2HC-type containing 1A	4
<a href="#">1102</a>	RCBTB2	RCC1 and BTB domain containing protein 2	4
<a href="#">2752</a>	GLUL	glutamate-ammonia ligase	4
<a href="#">3123</a>	HLA-DRB1	major histocompatibility complex, class II, DR beta 1	4
<a href="#">23608</a>	MKRN1	makorin ring finger protein 1	4
<a href="#">5429</a>	POLH	DNA polymerase eta	4
<a href="#">100507463</a>	PSMB8-AS1	PSMB8 antisense RNA 1 (head to head)	4
<a href="#">4261</a>	CITA	class II major histocompatibility complex transactivator	4
<a href="#">6916</a>	TBXAS1	thromboxane A synthase 1	4
<a href="#">116496</a>	FAM129A	family with sequence similarity 129 member A	4
<a href="#">643911</a>	CRNDE	colorectal neoplasia differentially expressed (non-protein coding)	4
<a href="#">4094</a>	MAF	MAF bZIP transcription factor	4
<a href="#">10788</a>	IQGAP2	IQ motif containing GTPase activating protein 2	4
<a href="#">3122</a>	HLA-DRA	major histocompatibility complex, class II, DR alpha	4
<a href="#">3113</a>	HLA-DPA1	major histocompatibility complex, class II, DP alpha 1	4
<a href="#">196527</a>	ANO6	anoctamin 6	4
<a href="#">10370</a>	CITED2	Cbp/p300 interacting transactivator with Glu/Asp rich carboxy-terminal domain 2	4
<a href="#">941</a>	CD80	CD80 molecule	4
<a href="#">202</a>	AIM1	absent in melanoma 1	4
<a href="#">2664</a>	GDI1	GDP dissociation inhibitor 1	4
<a href="#">6609</a>	SMPD1	sphingomyelin phosphodiesterase 1	4
<a href="#">84138</a>	SLC7A6OS	solute carrier family 7 member 6 opposite strand	4
<a href="#">254251</a>	LCORL	ligand dependent nuclear receptor corepressor like	4
<a href="#">2643</a>	GCH1	GTP cyclohydrolase 1	4
<a href="#">1633</a>	DCK	deoxycytidine kinase	4
<a href="#">64127</a>	NOD2	nucleotide binding oligomerization domain containing 2	4
<a href="#">51061</a>	TXNDC11	thioredoxin domain containing 11	4
<a href="#">5451</a>	POU2F1	POU class 2 homeobox 1	4
<a href="#">29968</a>	PSAT1	phosphoserine aminotransferase 1	4
<a href="#">4939</a>	OAS2	2'-5'-oligoadenylate synthetase 2	4
<a href="#">669</a>	BPGM	bisphosphoglycerate mutase	4
<a href="#">5165</a>	PDK3	pyruvate dehydrogenase kinase 3	4
<a href="#">79823</a>	CAMKMT	calmodulin-lysine N-methyltransferase	4
<a href="#">1979</a>	EIF4EBP2	eukaryotic translation initiation factor 4E binding protein 2	4
<a href="#">54495</a>	TMX3	thioredoxin related transmembrane protein 3	4
<a href="#">80350</a>	LPAL2	lipoprotein(a) like 2, pseudogene	4
<a href="#">51703</a>	ACSL5	acyl-CoA synthetase long-chain family member 5	4
<a href="#">4267</a>	CD99	CD99 molecule	4
<a href="#">152007</a>	GLIPR2	GLI pathogenesis related 2	4
<a href="#">79071</a>	ELOVL6	ELOVL fatty acid elongase 6	4
<a href="#">26277</a>	TINF2	TERF1 interacting nuclear factor 2	4
<a href="#">388323</a>	GLTPD2	glycolipid transfer protein domain containing 2	5
<a href="#">348262</a>	MCRIP1	MAPK regulated corepressor interacting protein 1	5
<a href="#">770</a>	CA11	carbonic anhydrase 11	5
<a href="#">140606</a>	SELENOM	selenoprotein M	5
<a href="#">7643</a>	ZNF90	zinc finger protein 90	5
<a href="#">5118</a>	PCOLCE	procollagen C-endopeptidase enhancer	5
<a href="#">27113</a>	BBC3	BCL2 binding component 3	5
<a href="#">60</a>	ACTB	actin beta	5
<a href="#">4137</a>	MAPT	microtubule associated protein tau	5
<a href="#">2051</a>	EPHB6	EPH receptor B6	5
<a href="#">9435</a>	CHST2	carbohydrate sulfotransferase 2	5
<a href="#">810</a>	CALML3	calmodulin like 3	5
<a href="#">84513</a>	PLPP5	phospholipid phosphatase 5	5
<a href="#">1406</a>	CRX	cone-rod homeobox	5
<a href="#">23178</a>	PASK	PAS domain containing serine/threonine kinase	5

<a href="#">84310</a>	C7orf50	chromosome 7 open reading frame 50	5
<a href="#">56125</a>	PCDHB11	protocadherin beta 11	5
<a href="#">440073</a>	IQSEC3	IQ motif and Sec7 domain 3	5
<a href="#">2889</a>	RAPGEF1	Rap guanine nucleotide exchange factor 1	5
<a href="#">865</a>	CBFB	core-binding factor beta subunit	5
<a href="#">157</a>	GRK3	G protein-coupled receptor kinase 3	5
<a href="#">100462981</a>	MTRNR2L2	MT-RNR2-like 2	5
<a href="#">51764</a>	GNG13	G protein subunit gamma 13	5
<a href="#">353134</a>	LCE1D	late cornified envelope 1D	5
<a href="#">64743</a>	WDR13	WD repeat domain 13	5
<a href="#">80194</a>	TMEM134	transmembrane protein 134	5
<a href="#">23678</a>	SGK3	serum/glucocorticoid regulated kinase family member 3	5
<a href="#">115703</a>	ARHGAP33	Rho GTPase activating protein 33	5
<a href="#">100316904</a>	SAP25	Sin3A associated protein 25	5
<a href="#">256949</a>	KANK3	KN motif and ankyrin repeat domains 3	5
<a href="#">9990</a>	SLC12A6	solute carrier family 12 member 6	5
<a href="#">83593</a>	RASSF5	Ras association domain family member 5	5
<a href="#">126695</a>	KDF1	keratinocyte differentiation factor 1	5
<a href="#">100130958</a>	SYCE1L	synaptonemal complex central element protein 1 like	5
<a href="#">286075</a>	ZNF707	zinc finger protein 707	5
<a href="#">85407</a>	NKD1	naked cuticle homolog 1	5
<a href="#">753</a>	LDLRAD4	low density lipoprotein receptor class A domain containing 4	5
<a href="#">23417</a>	MLYCD	malonyl-CoA decarboxylase	5
<a href="#">284723</a>	SLC25A34	solute carrier family 25 member 34	5
<a href="#">348013</a>	TMEM255B	transmembrane protein 255B	5
<a href="#">85027</a>	SMIM3	small integral membrane protein 3	5
<a href="#">388595</a>	TMEM82	transmembrane protein 82	5
<a href="#">535</a>	ATP6V0A1	ATPase H <sup>+</sup> transporting V0 subunit a1	5
<a href="#">9531</a>	BAG3	BCL2 associated athanogene 3	5
<a href="#">915</a>	CD3D	CD3d molecule	5
<a href="#">10507</a>	SEMA4D	semaphorin 4D	5
<a href="#">56940</a>	DUSP22	dual specificity phosphatase 22	5
<a href="#">55030</a>	FBXO34	F-box protein 34	5
<a href="#">10765</a>	KDM5B	lysine demethylase 5B	5
<a href="#">921</a>	CD5	CD5 molecule	5
<a href="#">6223</a>	RPS19	ribosomal protein S19	5
<a href="#">132299</a>	OCIAD2	OCIA domain containing 2	5
<a href="#">341567</a>	H1FNT	H1 histone family member N, testis specific	5
<a href="#">64061</a>	TSPYL2	TSPY like 2	5
<a href="#">27086</a>	FOXP1	forkhead box P1	5
<a href="#">6821</a>	SUOX	sulfite oxidase	5
<a href="#">57092</a>	PCNP	PEST proteolytic signal containing nuclear protein	5
<a href="#">93145</a>	OLFM2	olfactomedin 2	5
<a href="#">129804</a>	FBLN7	fibulin 7	5
<a href="#">79778</a>	MICALL2	MICAL like 2	5
<a href="#">1514</a>	CTSL	cathepsin L	5
<a href="#">1543</a>	CYP1A1	cytochrome P450 family 1 subfamily A member 1	5
<a href="#">23275</a>	POFUT2	protein O-fucosyltransferase 2	5
<a href="#">148223</a>	C19orf25	chromosome 19 open reading frame 25	5
<a href="#">268</a>	AMH	anti-Mullerian hormone	5
<a href="#">10362</a>	HMG20B	high mobility group 20B	5
<a href="#">116983</a>	ACAP3	ArfGAP with coiled-coil, ankyrin repeat and PH domains 3	5
<a href="#">9792</a>	SERTAD2	SERTA domain containing 2	5
<a href="#">9057</a>	SLC7A6	solute carrier family 7 member 6	5
<a href="#">5209</a>	PFKFB3	6-phosphofructo-2-kinase/fructose-2,6-biphosphatase 3	5
<a href="#">84947</a>	SERAC1	serine active site containing 1	5
<a href="#">10927</a>	SPIN1	spindlin 1	5
<a href="#">100463487</a>	MTRNR2L9	MT-RNR2-like 9	5
<a href="#">203522</a>	INTS6L	integrator complex subunit 6 like	5
<a href="#">94235</a>	GNG8	G protein subunit gamma 8	5
<a href="#">6001</a>	RGS10	regulator of G-protein signaling 10	5
<a href="#">54947</a>	LPCAT2	lysophosphatidylcholine acyltransferase 2	5
<a href="#">659</a>	BMPR2	bone morphogenetic protein receptor type 2	5
<a href="#">23479</a>	ISCU	iron-sulfur cluster assembly enzyme	5
<a href="#">100287898</a>	TTC34	tetratricopeptide repeat domain 34	5

<a href="#">2908</a>	NR3C1	nuclear receptor subfamily 3 group C member 1	5
<a href="#">6229</a>	RPS24	ribosomal protein S24	5
<a href="#">29121</a>	CLEC2D	C-type lectin domain family 2 member D	5
<a href="#">25893</a>	TRIM58	tripartite motif containing 58	5
<a href="#">29095</a>	ORMDL2	ORMDL sphingolipid biosynthesis regulator 2	5
<a href="#">104</a>	ADARB1	adenosine deaminase, RNA specific B1	5
<a href="#">5272</a>	SERPINB9	serpin family B member 9	5
<a href="#">284611</a>	FAM102B	family with sequence similarity 102 member B	5
<a href="#">27248</a>	ERLEC1	endoplasmic reticulum lectin 1	5
<a href="#">10982</a>	MAPRE2	microtubule associated protein RP/EB family member 2	5
<a href="#">6794</a>	STK11	serine/threonine kinase 11	5
<a href="#">3831</a>	KLC1	kinesin light chain 1	5
<a href="#">6242</a>	RTKN	rhotekin	5
<a href="#">57680</a>	CHD8	chromodomain helicase DNA binding protein 8	5
<a href="#">85364</a>	ZCCHC3	zinc finger CCHC-type containing 3	5
<a href="#">163126</a>	EID2	EP300 interacting inhibitor of differentiation 2	5
<a href="#">650669</a>	GAS6-AS1	GAS6 antisense RNA 1	5
<a href="#">55893</a>	ZNF395	zinc finger protein 395	5
<a href="#">26228</a>	STAP1	signal transducing adaptor family member 1	5
<a href="#">51225</a>	ABI3	ABI family member 3	5
<a href="#">7187</a>	TRAF3	TNF receptor associated factor 3	5
<a href="#">196</a>	AHR	aryl hydrocarbon receptor	5
<a href="#">728747</a>	ANKRD20A4	ankyrin repeat domain 20 family member A4	5
<a href="#">389333</a>	PROB1	proline rich basic protein 1	5
<a href="#">11202</a>	KLK8	kallikrein related peptidase 8	5
<a href="#">2530</a>	FUT8	fucosyltransferase 8	5
<a href="#">6224</a>	RPS20	ribosomal protein S20	5
<a href="#">55636</a>	CHD7	chromodomain helicase DNA binding protein 7	5
<a href="#">10188</a>	TNK2	tyrosine kinase non receptor 2	5
<a href="#">170067</a>	SUPT20HL2	SPT20 homolog, SAGA complex component-like 2	5
<a href="#">4363</a>	ABCC1	ATP binding cassette subfamily C member 1	5
<a href="#">581</a>	BAX	BCL2 associated X, apoptosis regulator	5
<a href="#">7529</a>	YWHAH	tyrosine 3-monooxygenase/tryptophan 5-monooxygenase activation protein beta	5
<a href="#">60468</a>	BACH2	BTB domain and CNC homolog 2	5
<a href="#">57491</a>	AHRR	aryl-hydrocarbon receptor repressor	5
<a href="#">730098</a>	LOC730098	uncharacterized LOC730098	5
<a href="#">221937</a>	FOXK1	forkhead box K1	5
<a href="#">729020</a>	RPEL1	ribulose-5-phosphate-3-epimerase like 1	5
<a href="#">4082</a>	MARCKS	myristoylated alanine rich protein kinase C substrate	5
<a href="#">5290</a>	PIK3CA	phosphatidylinositol-4,5-bisphosphate 3-kinase catalytic subunit alpha	5
<a href="#">63971</a>	KIF13A	kinesin family member 13A	5
<a href="#">9794</a>	MAML1	mastermind like transcriptional coactivator 1	5
<a href="#">80045</a>	GPR157	G protein-coupled receptor 157	5
<a href="#">3097</a>	HIVEP2	human immunodeficiency virus type 1 enhancer binding protein 2	5
<a href="#">7044</a>	LEFTY2	left-right determination factor 2	5
<a href="#">222658</a>	KCTD20	potassium channel tetramerization domain containing 20	5
<a href="#">399668</a>	SMIM10L2A	small integral membrane protein 10 like 2A	5
<a href="#">125058</a>	TBC1D16	TBC1 domain family member 16	5
<a href="#">5753</a>	PTK6	protein tyrosine kinase 6	5
<a href="#">65986</a>	ZBTB10	zinc finger and BTB domain containing 10	5
<a href="#">727957</a>	MROH1	maestro heat like repeat family member 1	5
<a href="#">2779</a>	GNAT1	G protein subunit alpha transducin 1	5
<a href="#">376497</a>	SLC27A1	solute carrier family 27 member 1	5
<a href="#">1427</a>	CRYGS	crystallin gamma S	5
<a href="#">440955</a>	TMEM89	transmembrane protein 89	5
<a href="#">9883</a>	POM121	POM121 transmembrane nucleoporin	5
<a href="#">54863</a>	TOR4A	torsin family 4 member A	5
<a href="#">8878</a>	SQSTM1	sequestosome 1	5
<a href="#">414318</a>	C9orf106	chromosome 9 open reading frame 106	5
<a href="#">7146</a>	TNXA	tenascin XA (pseudogene)	5
<a href="#">6498</a>	SKIL	SKI like proto-oncogene	5
<a href="#">3090</a>	HIC1	hypermethylated in cancer 1	5
<a href="#">22877</a>	MLXIP	MLX interacting protein	5
<a href="#">3853</a>	KRT6A	keratin 6A	5
<a href="#">84878</a>	ZBTB45	zinc finger and BTB domain containing 45	5

<a href="#">359948</a>	IRF2BP2	interferon regulatory factor 2 binding protein 2	5
<a href="#">23505</a>	TMEM131	transmembrane protein 131	5
<a href="#">10489</a>	LRRC41	leucine rich repeat containing 41	5
<a href="#">717</a>	C2	complement C2	5
<a href="#">10014</a>	HDAC5	histone deacetylase 5	5
<a href="#">3910</a>	LAMA4	laminin subunit alpha 4	5
<a href="#">6623</a>	SNCG	synuclein gamma	5
<a href="#">90427</a>	BMF	Bcl2 modifying factor	5
<a href="#">6209</a>	RPS15	ribosomal protein S15	5
<a href="#">6205</a>	RPS11	ribosomal protein S11	5
<a href="#">6217</a>	RPS16	ribosomal protein S16	5
<a href="#">158376</a>	LINC00961	long intergenic non-protein coding RNA 961	5
<a href="#">79791</a>	FBXO31	F-box protein 31	5
<a href="#">54795</a>	TRPM4	transient receptor potential cation channel subfamily M member 4	5
<a href="#">7791</a>	ZYX	zyxin	5
<a href="#">123920</a>	CMTM3	CKLF like MARVEL transmembrane domain containing 3	5
<a href="#">3718</a>	JAK3	Janus kinase 3	5
<a href="#">11336</a>	EXOC3	exocyst complex component 3	5
<a href="#">23293</a>	SMG6	SMG6, nonsense mediated mRNA decay factor	5
<a href="#">7048</a>	TGFBR2	transforming growth factor beta receptor 2	5
<a href="#">9094</a>	UNC119	unc-119 lipid binding chaperone	5
<a href="#">2869</a>	GRK5	G protein-coupled receptor kinase 5	5
<a href="#">8728</a>	ADAM19	ADAM metallopeptidase domain 19	5
<a href="#">10800</a>	CYSLTR1	cysteinyl leukotriene receptor 1	5
<a href="#">4088</a>	SMAD3	SMAD family member 3	5
<a href="#">3927</a>	LASP1	LIM and SH3 protein 1	5
<a href="#">178</a>	AGL	amylase alpha-1, 6-glucosidase, 4-alpha-glucanotransferase	5
<a href="#">25766</a>	PRPF40B	pre-mRNA processing factor 40 homolog B	5
<a href="#">1455</a>	CSNK1G2	casein kinase 1 gamma 2	5
<a href="#">5878</a>	RAB5C	RAB5C, member RAS oncogene family	5
<a href="#">2997</a>	GYS1	glycogen synthase 1	5
<a href="#">80152</a>	CENPT	centromere protein T	5
<a href="#">940</a>	CD28	CD28 molecule	5
<a href="#">79897</a>	RPP21	ribonuclease P/MRP subunit p21	5
<a href="#">155061</a>	ZNF746	zinc finger protein 746	5
<a href="#">6665</a>	SOX15	SRY-box 15	5
<a href="#">79144</a>	PPDPF	pancreatic progenitor cell differentiation and proliferation factor	5
<a href="#">169981</a>	SPIN3	spindlin family member 3	5
<a href="#">23338</a>	JADE2	jade family PHD finger 2	5
<a href="#">3707</a>	ITPKB	inositol-trisphosphate 3-kinase B	5
<a href="#">9896</a>	FIG4	FIG4 phosphoinositide 5-phosphatase	5
<a href="#">23144</a>	ZC3H3	zinc finger CCCH-type containing 3	5
<a href="#">57479</a>	PRR12	proline rich 12	5
<a href="#">9143</a>	SYNGR3	synaptogyrin 3	5
<a href="#">80774</a>	LIMD2	LIM domain containing 2	5
<a href="#">11337</a>	GABARAP	GABA type A receptor-associated protein	5
<a href="#">54543</a>	TOMM7	translocase of outer mitochondrial membrane 7	5
<a href="#">10567</a>	RABAC1	Rab acceptor 1	5
<a href="#">64319</a>	FBRS	fibrosin	5
<a href="#">6227</a>	RPS21	ribosomal protein S21	5
<a href="#">29123</a>	ANKRD11	ankyrin repeat domain 11	5
<a href="#">4041</a>	LRP5	LDL receptor related protein 5	5
<a href="#">64375</a>	IKZF4	IKAROS family zinc finger 4	5
<a href="#">100652768</a>	LOC100652768	uncharacterized LOC100652768	5
<a href="#">6137</a>	RPL13	ribosomal protein L13	5
<a href="#">219968</a>	ORSB21	olfactory receptor family 5 subfamily B member 21	5
<a href="#">6135</a>	RPL11	ribosomal protein L11	5
<a href="#">201163</a>	FLCN	folliculin	5
<a href="#">100507347</a>	VIM-AS1	VIM antisense RNA 1	5
<a href="#">57154</a>	SMURF1	SMAD specific E3 ubiquitin protein ligase 1	5
<a href="#">5128</a>	CDK17	cyclin dependent kinase 17	5
<a href="#">6208</a>	RPS14	ribosomal protein S14	5
<a href="#">10169</a>	SERF2	small EDRK-rich factor 2	5
<a href="#">4215</a>	MAP3K3	mitogen-activated protein kinase kinase kinase 3	5
<a href="#">939</a>	CD27	CD27 molecule	5

<a href="#">272</a>	AMPD3	adenosine monophosphate deaminase 3	5
<a href="#">27287</a>	VENTX	VENT homeobox	5
<a href="#">23094</a>	SIPA1L3	signal induced proliferation associated 1 like 3	5
<a href="#">54463</a>	FAM134B	family with sequence similarity 134 member B	5
<a href="#">57713</a>	SFMBT2	Scm-like with four mbt domains 2	5
<a href="#">80003</a>	PCNX2	pecanex homolog 2 (Drosophila)	5
<a href="#">22852</a>	ANKRD26	ankyrin repeat domain 26	5
<a href="#">55626</a>	AMBRA1	autophagy and beclin 1 regulator 1	5
<a href="#">5339</a>	PLEC	plectin	5
<a href="#">55914</a>	ERBIN	erbB2 interacting protein	5
<a href="#">5900</a>	RALGDS	ral guanine nucleotide dissociation stimulator	5
<a href="#">23196</a>	FAM120A	family with sequence similarity 120A	5
<a href="#">2634</a>	GBP2	guanylate binding protein 2	5
<a href="#">6156</a>	RPL30	ribosomal protein L30	5
<a href="#">246175</a>	CNOT6L	CCR4-NOT transcription complex subunit 6 like	5
<a href="#">9806</a>	SPOCK2	SPARC/osteonectin, cwcv and kazal like domains proteoglycan 2	5
<a href="#">29997</a>	GLTSCR2	glioma tumor suppressor candidate region gene 2	5
<a href="#">5144</a>	PDE4D	phosphodiesterase 4D	5
<a href="#">25976</a>	TIPARP	TCDD inducible poly(ADP-ribose) polymerase	5
<a href="#">25865</a>	PRKD2	protein kinase D2	5
<a href="#">4209</a>	MEF2D	myocyte enhancer factor 2D	5
<a href="#">23077</a>	MYCBP2	MYC binding protein 2, E3 ubiquitin protein ligase	5
<a href="#">57448</a>	BIRC6	baculoviral IAP repeat containing 6	5
<a href="#">645843</a>	TMEM14EP	transmembrane protein 14E, pseudogene	5
<a href="#">10326</a>	SIRPB1	signal regulatory protein beta 1	5
<a href="#">55668</a>	GPATCH2L	G-patch domain containing 2 like	5
<a href="#">81855</a>	SFXN3	sideroflexin 3	5
<a href="#">9404</a>	LPXN	leupaxin	5
<a href="#">6575</a>	SLC20A2	solute carrier family 20 member 2	5
<a href="#">64748</a>	PLPPR2	phospholipid phosphatase related 2	5
<a href="#">284346</a>	ZNF575	zinc finger protein 575	5
<a href="#">55558</a>	PLXNA3	plexin A3	5
<a href="#">646962</a>	HRCT1	histidine rich carboxyl terminus 1	5
<a href="#">1564</a>	CYP2D7	cytochrome P450 family 2 subfamily D member 7 (gene/pseudogene)	5
<a href="#">7094</a>	TLN1	talin 1	5
<a href="#">130013</a>	ACMSD	aminocarboxymuconate semialdehyde decarboxylase	5
<a href="#">57787</a>	MARK4	microtubule affinity regulating kinase 4	5
<a href="#">55690</a>	PACS1	phosphofurin acidic cluster sorting protein 1	5
<a href="#">81844</a>	TRIM56	tripartite motif containing 56	5
<a href="#">196743</a>	PAOX	polyamine oxidase	5
<a href="#">116985</a>	ARAP1	ArfGAP with RhoGAP domain, ankyrin repeat and PH domain 1	5
<a href="#">65056</a>	GPBP1	GC-rich promoter binding protein 1	5
<a href="#">84033</a>	OBSCN	obscurin, cytoskeletal calmodulin and titin-interacting RhoGEF	5
<a href="#">283600</a>	SLC25A47	solute carrier family 25 member 47	5
<a href="#">7291</a>	TWIST1	twist family bHLH transcription factor 1	5
<a href="#">201294</a>	UNC13D	unc-13 homolog D	5
<a href="#">100996693</a>	LOC100996693	CAVP-target protein-like	5
<a href="#">64781</a>	CERK	ceramide kinase	5
<a href="#">146206</a>	CARMIL2	capping protein regulator and myosin 1 linker 2	5
<a href="#">653583</a>	PHLDB3	pleckstrin homology like domain family B member 3	5
<a href="#">283385</a>	MORN3	MORN repeat containing 3	5
<a href="#">352954</a>	GATS	GATS, stromal antigen 3 opposite strand	5
<a href="#">7379</a>	UPK2	uroplakin 2	5
<a href="#">29882</a>	ANAPC2	anaphase promoting complex subunit 2	5
<a href="#">1535</a>	CYBA	cytochrome b-245 alpha chain	5
<a href="#">5093</a>	PCBP1	poly(rC) binding protein 1	5
<a href="#">79958</a>	DENND1C	DENN domain containing 1C	5
<a href="#">79156</a>	PLEKHF1	pleckstrin homology and FYVE domain containing 1	5
<a href="#">60684</a>	TRAPPC11	trafficking protein particle complex 11	5
<a href="#">9821</a>	RB1CC1	RB1 inducible coiled-coil 1	5
<a href="#">84256</a>	FLYWCH1	FLYWCH-type zinc finger 1	5
<a href="#">51669</a>	SARAF	store-operated calcium entry associated regulatory factor	5
<a href="#">51343</a>	FZR1	fizzy/cell division cycle 20 related 1	5
<a href="#">8398</a>	PLA2G6	phospholipase A2 group VI	5
<a href="#">54434</a>	SSH1	slingshot protein phosphatase 1	5

<a href="#">2588</a>	GALNS	galactosamine (N-acetyl)-6-sulfatase	5
<a href="#">399669</a>	ZNF321P	zinc finger protein 321, pseudogene	5
<a href="#">2621</a>	GAS6	growth arrest specific 6	5
<a href="#">57558</a>	USP35	ubiquitin specific peptidase 35	5
<a href="#">284439</a>	SLC25A42	solute carrier family 25 member 42	5
<a href="#">6181</a>	RPLP2	ribosomal protein lateral stalk subunit P2	5
<a href="#">90625</a>	ERVH48-1	endogenous retrovirus group 48 member 1	5
<a href="#">4753</a>	NELL2	neural EGFL like 2	5
<a href="#">6222</a>	RPS18	ribosomal protein S18	5
<a href="#">50840</a>	TAS2R14	taste 2 receptor member 14	5
<a href="#">11215</a>	AKAP11	A-kinase anchoring protein 11	5
<a href="#">81619</a>	TSPAN14	tetraspanin 14	5
<a href="#">9448</a>	MAP4K4	mitogen-activated protein kinase kinase kinase 4	5
<a href="#">7750</a>	ZMYM2	zinc finger MYM-type containing 2	5
<a href="#">10806</a>	SDCCAG8	serologically defined colon cancer antigen 8	5
<a href="#">158078</a>	EEF1A1P5	eukaryotic translation elongation factor 1 alpha 1 pseudogene 5	5
<a href="#">6228</a>	RPS23	ribosomal protein S23	5
<a href="#">55423</a>	SIRPG	signal regulatory protein gamma	5
<a href="#">919</a>	CD247	CD247 molecule	5
<a href="#">1890</a>	TYMP	thymidine phosphorylase	5
<a href="#">8553</a>	BHLHE40	basic helix-loop-helix family member e40	5
<a href="#">162972</a>	ZNF550	zinc finger protein 550	5
<a href="#">60401</a>	EDA2R	ectodysplasin A2 receptor	5
<a href="#">192668</a>	CYS1	cystin 1	5
<a href="#">57634</a>	EP400	E1A binding protein p400	5
<a href="#">91252</a>	SLC39A13	solute carrier family 39 member 13	5
<a href="#">11117</a>	EMILIN1	elastin microfibril interfacier 1	5
<a href="#">51315</a>	KRCC1	lysine rich coiled-coil 1	5
<a href="#">114132</a>	SIGLEC11	sialic acid binding Ig like lectin 11	5
<a href="#">5498</a>	PPOX	protoporphyrinogen oxidase	5
<a href="#">112574</a>	SNX18	sorting nexin 18	5
<a href="#">58480</a>	RHOU	ras homolog family member U	5
<a href="#">260425</a>	MAGI3	membrane associated guanylate kinase, WW and PDZ domain containing 3	5
<a href="#">65998</a>	C11orf95	chromosome 11 open reading frame 95	5
<a href="#">23743</a>	BHMT2	betaine--homocysteine S-methyltransferase 2	5
<a href="#">23492</a>	CBX7	chromobox 7	5
<a href="#">58509</a>	CACTIN	cactin, spliceosome C complex subunit	5
<a href="#">27106</a>	ARRDC2	arrestin domain containing 2	5
<a href="#">23053</a>	ZSWIM8	zinc finger SWIM-type containing 8	5
<a href="#">1294</a>	COL7A1	collagen type VII alpha 1 chain	5
<a href="#">79095</a>	C9orf16	chromosome 9 open reading frame 16	5
<a href="#">7753</a>	ZNF202	zinc finger protein 202	5
<a href="#">116535</a>	MRGPRF	MAS related GPR family member F	5
<a href="#">5199</a>	CFP	complement factor properdin	5
<a href="#">8792</a>	TNFRSF11A	TNF receptor superfamily member 11a	5
<a href="#">259234</a>	DSCR10	Down syndrome critical region 10 (non-protein coding)	5
<a href="#">6123</a>	RPL3L	ribosomal protein L3 like	5
<a href="#">23352</a>	UBR4	ubiquitin protein ligase E3 component n-recognin 4	5
<a href="#">375033</a>	PEAR1	platelet endothelial aggregation receptor 1	5
<a href="#">10908</a>	PNPLA6	patatin like phospholipase domain containing 6	5
<a href="#">22863</a>	ATG14	autophagy related 14	5
<a href="#">4302</a>	MLLT6	MLLT6, PHD finger domain containing	5
<a href="#">23265</a>	EXOC7	exocyst complex component 7	5
<a href="#">1236</a>	CCR7	C-C motif chemokine receptor 7	5
<a href="#">126393</a>	HSPB6	heat shock protein family B (small) member 6	5
<a href="#">9701</a>	PPP6R2	protein phosphatase 6 regulatory subunit 2	5
<a href="#">5075</a>	PAX1	paired box 1	5
<a href="#">126282</a>	TNFAIP8L1	TNF alpha induced protein 8 like 1	5
<a href="#">25950</a>	RWDD3	RWD domain containing 3	5
<a href="#">146542</a>	ZNF688	zinc finger protein 688	5
<a href="#">56124</a>	PCDHB12	protocadherin beta 12	5
<a href="#">90987</a>	ZNF251	zinc finger protein 251	5
<a href="#">101060376</a>	TBC1D3L	TBC1 domain family member 3L	5
<a href="#">337867</a>	UBAC2	UBA domain containing 2	5
<a href="#">678</a>	ZFP36L2	ZFP36 ring finger protein like 2	5

<a href="#">6155</a>	RPL27	ribosomal protein L27	5
<a href="#">924</a>	CD7	CD7 molecule	5
<a href="#">5869</a>	RAB5B	RAB5B, member RAS oncogene family	5
<a href="#">2687</a>	GGT5	gamma-glutamyltransferase 5	5
<a href="#">3455</a>	IFNAR2	interferon alpha and beta receptor subunit 2	5
<a href="#">55114</a>	ARHGAP17	Rho GTPase activating protein 17	5
<a href="#">23300</a>	ATMIN	ATM interactor	5
<a href="#">23157</a>	SEPT6	septin 6	5
<a href="#">84433</a>	CARD11	caspase recruitment domain family member 11	5
<a href="#">9363</a>	RAB33A	RAB33A, member RAS oncogene family	5
<a href="#">23410</a>	SIRT3	sirtuin 3	5
<a href="#">6141</a>	RPL18	ribosomal protein L18	5
<a href="#">4092</a>	SMAD7	SMAD family member 7	5
<a href="#">256281</a>	NUDT14	nudix hydrolase 14	5
<a href="#">222234</a>	FAM185A	family with sequence similarity 185 member A	5
<a href="#">126259</a>	TMIGD2	transmembrane and immunoglobulin domain containing 2	5
<a href="#">84441</a>	MAML2	mastermind like transcriptional coactivator 2	5
<a href="#">80162</a>	PGGHG	protein-glucosylgalactosylhydroxylysine glucosidase	5
<a href="#">56995</a>	TULP4	tubby like protein 4	5
<a href="#">5013</a>	OTX1	orthodenticle homeobox 1	5
<a href="#">79818</a>	ZNF552	zinc finger protein 552	5
<a href="#">4356</a>	MPP3	membrane palmitoylated protein 3	5
<a href="#">23770</a>	FKBP8	FK506 binding protein 8	5
<a href="#">346689</a>	KLRG2	killer cell lectin like receptor G2	5
<a href="#">256021</a>	LINC01619	long intergenic non-protein coding RNA 1619	5
<a href="#">9644</a>	SH3PXD2A	SH3 and PX domains 2A	5
<a href="#">1384</a>	CRAT	carnitine O-acetyltransferase	5
<a href="#">4925</a>	NUCB2	nucleobindin 2	5
<a href="#">8839</a>	WISP2	WNT1 inducible signaling pathway protein 2	5
<a href="#">27243</a>	CHMP2A	charged multivesicular body protein 2A	5
<a href="#">5333</a>	PLCD1	phospholipase C delta 1	5
<a href="#">309</a>	ANXA6	annexin A6	5
<a href="#">3561</a>	IL2RG	interleukin 2 receptor subunit gamma	5
<a href="#">79705</a>	LRRK1	leucine rich repeat kinase 1	5
<a href="#">100874214</a>	TM4SF19-AS1	TM4SF19 antisense RNA 1	5
<a href="#">200035</a>	NUDT17	nudix hydrolase 17	5
<a href="#">3299</a>	HSF4	heat shock transcription factor 4	5
<a href="#">974</a>	CD79B	CD79b molecule	5
<a href="#">9423</a>	NTN1	netrin 1	5
<a href="#">100128675</a>	HPN-AS1	HPN antisense RNA 1	5
<a href="#">51005</a>	AMDHD2	amidohydrolase domain containing 2	5
<a href="#">64806</a>	IL25	interleukin 25	5
<a href="#">26127</a>	FGFR1OP2	FGFR1 oncogene partner 2	5
<a href="#">101060684</a>	NBPF26	neuroblastoma breakpoint family member 26	5
<a href="#">55204</a>	GOLPH3L	golgi phosphoprotein 3 like	5
<a href="#">163087</a>	ZNF383	zinc finger protein 383	5
<a href="#">83941</a>	TM2D1	TM2 domain containing 1	5
<a href="#">10780</a>	ZNF234	zinc finger protein 234	5
<a href="#">55844</a>	PPP2R2D	protein phosphatase 2 regulatory subunit Bdelta	5
<a href="#">36</a>	ACADSB	acyl-CoA dehydrogenase, short/branched chain	5
<a href="#">6342</a>	SCP2	sterol carrier protein 2	5
<a href="#">219749</a>	ZNF25	zinc finger protein 25	5
<a href="#">348094</a>	ANKDD1A	ankyrin repeat and death domain containing 1A	5
<a href="#">51111</a>	KMT5B	lysine methyltransferase 5B	5
<a href="#">55337</a>	C19orf66	chromosome 19 open reading frame 66	5
<a href="#">1731</a>	SEPT1	septin 1	5
<a href="#">11226</a>	GALNT6	polypeptide N-acetylgalactosaminyltransferase 6	5
<a href="#">55900</a>	ZNF302	zinc finger protein 302	5
<a href="#">132160</a>	PPM1M	protein phosphatase, Mg <sup>2+</sup> /Mn <sup>2+</sup> dependent 1M	5
<a href="#">6775</a>	STAT4	signal transducer and activator of transcription 4	5
<a href="#">28951</a>	TRIB2	tribbles pseudokinase 2	5
<a href="#">1891</a>	ECH1	enoyl-CoA hydratase 1	5
<a href="#">8195</a>	MKKS	McKusick-Kaufman syndrome	5
<a href="#">388969</a>	C2orf68	chromosome 2 open reading frame 68	5
<a href="#">9087</a>	TMSB4Y	thymosin beta 4, Y-linked	5

<a href="#">51247</a>	PAIP2	poly(A) binding protein interacting protein 2	5
<a href="#">11060</a>	WWP2	WW domain containing E3 ubiquitin protein ligase 2	5
<a href="#">8434</a>	RECK	reversion inducing cysteine rich protein with kazal motifs	5
<a href="#">5412</a>	UBL3	ubiquitin like 3	5
<a href="#">55501</a>	CHST12	carbohydrate sulfotransferase 12	5
<a href="#">83463</a>	MXD3	MAX dimerization protein 3	5
<a href="#">55251</a>	PCMTD2	protein-L-isoaspartate (D-aspartate) O-methyltransferase domain containing 2	5
<a href="#">115817</a>	DHRS1	dehydrogenase/reductase 1	5
<a href="#">10916</a>	MAGED2	MAGE family member D2	5
<a href="#">26152</a>	ZNF337	zinc finger protein 337	5
<a href="#">6158</a>	RPL28	ribosomal protein L28	5
<a href="#">54532</a>	USP53	ubiquitin specific peptidase 53	5
<a href="#">1195</a>	CLK1	CDC like kinase 1	5
<a href="#">55219</a>	TMEM57	transmembrane protein 57	5
<a href="#">2778</a>	GNAS	GNAS complex locus	5
<a href="#">9746</a>	CLSTN3	calsynenin 3	5
<a href="#">23523</a>	CABIN1	calcineurin binding protein 1	5
<a href="#">100131187</a>	TSTD1	thiosulfate sulfurtransferase like domain containing 1	5
<a href="#">4007</a>	PRICKLE3	prickle planar cell polarity protein 3	5
<a href="#">339366</a>	ADAMTSL5	ADAMTS like 5	5
<a href="#">10045</a>	SH2D3A	SH2 domain containing 3A	5
<a href="#">79132</a>	DHX58	DEXH-box helicase 58	5
<a href="#">9522</a>	SCAMP1	secretory carrier membrane protein 1	5
<a href="#">11179</a>	ZNF277	zinc finger protein 277	5
<a href="#">4926</a>	NUMA1	nuclear mitotic apparatus protein 1	5
<a href="#">390927</a>	ZNF793	zinc finger protein 793	5
<a href="#">729238</a>	SFTPA2	surfactant protein A2	5
<a href="#">57132</a>	CHMP1B	charged multivesicular body protein 1B	5
<a href="#">56925</a>	LXN	latexin	5
<a href="#">3590</a>	IL11RA	interleukin 11 receptor subunit alpha	5
<a href="#">474344</a>	GIMAP6	GTPase, IMAP family member 6	5
<a href="#">1794</a>	DOCK2	dedicator of cytokinesis 2	5
<a href="#">255967</a>	PAN3	PAN3 poly(A) specific ribonuclease subunit	5
<a href="#">4627</a>	MYH9	myosin heavy chain 9	5
<a href="#">55187</a>	VPS13D	vacuolar protein sorting 13 homolog D	5
<a href="#">80325</a>	ABTB1	ankyrin repeat and BTB domain containing 1	5
<a href="#">8764</a>	TNFRSF14	TNF receptor superfamily member 14	5
<a href="#">23503</a>	ZFYVE26	zinc finger FYVE-type containing 26	5
<a href="#">9969</a>	MED13	mediator complex subunit 13	5
<a href="#">23230</a>	VPS13A	vacuolar protein sorting 13 homolog A	5
<a href="#">9354</a>	UBE4A	ubiquitination factor E4A	5
<a href="#">22992</a>	KDM2A	lysine demethylase 2A	5
<a href="#">113</a>	ADCY7	adenylate cyclase 7	5
<a href="#">5289</a>	PIK3C3	phosphatidylinositol 3-kinase catalytic subunit type 3	5
<a href="#">7155</a>	TOP2B	topoisomerase (DNA) II beta	5
<a href="#">6942</a>	TCF20	transcription factor 20	5
<a href="#">2316</a>	FLNA	filamin A	5
<a href="#">23550</a>	PSD4	pleckstrin and Sec7 domain containing 4	5
<a href="#">50839</a>	TAS2R10	taste 2 receptor member 10	5
<a href="#">23215</a>	PRRC2C	proline rich coiled-coil 2C	5
<a href="#">10838</a>	ZNF275	zinc finger protein 275	5
<a href="#">256364</a>	EML3	echinoderm microtubule associated protein like 3	5
<a href="#">56252</a>	YLPM1	YLP motif containing 1	5
<a href="#">25792</a>	CIZ1	CDKN1A interacting zinc finger protein 1	5
<a href="#">126374</a>	WTIP	Wilms tumor 1 interacting protein	5
<a href="#">147686</a>	ZNF418	zinc finger protein 418	5
<a href="#">23005</a>	MAPKBP1	mitogen-activated protein kinase binding protein 1	5
<a href="#">129530</a>	LYG1	lysozyme g1	5
<a href="#">64772</a>	ENGASE	endo-beta-N-acetylglucosaminidase	5
<a href="#">5585</a>	PKN1	protein kinase N1	5
<a href="#">114904</a>	C1QTNF6	C1q and tumor necrosis factor related protein 6	5
<a href="#">80320</a>	SP6	Sp6 transcription factor	5
<a href="#">63941</a>	NECAB3	N-terminal EF-hand calcium binding protein 3	5
<a href="#">8547</a>	FCN3	ficolin 3	5
<a href="#">115196</a>	ZNF554	zinc finger protein 554	5

<a href="#">7786</a>	MAP3K12	mitogen-activated protein kinase kinase kinase 12	5
<a href="#">673</a>	BRAF	B-Raf proto-oncogene, serine/threonine kinase	5
<a href="#">290</a>	ANPEP	alanyl aminopeptidase, membrane	5
<a href="#">64760</a>	FAM160B2	family with sequence similarity 160 member B2	5
<a href="#">51043</a>	ZBTB7B	zinc finger and BTB domain containing 7B	5
<a href="#">100126793</a>	GHRLOS	ghrelin opposite strand/antisense RNA	5
<a href="#">23002</a>	DAAM1	dishevelled associated activator of morphogenesis 1	5
<a href="#">9202</a>	ZMYM4	zinc finger MYM-type containing 4	5
<a href="#">6651</a>	SON	SON DNA binding protein	5
<a href="#">55209</a>	SETD5	SET domain containing 5	5
<a href="#">23592</a>	LEMD3	LEM domain containing 3	5
<a href="#">57683</a>	ZDBF2	zinc finger DBF-type containing 2	5
<a href="#">5062</a>	PAK2	p21 (RAC1) activated kinase 2	5
<a href="#">259282</a>	BOD1L1	biorientation of chromosomes in cell division 1 like 1	5
<a href="#">10396</a>	ATP8A1	ATPase phospholipid transporting 8A1	5
<a href="#">282809</a>	POC1B	POC1 centriolar protein B	5
<a href="#">63908</a>	NAPB	NSF attachment protein beta	5
<a href="#">284459</a>	HKR1	HKR1, GLI-Kruppel zinc finger family member	5
<a href="#">7392</a>	USF2	upstream transcription factor 2, c-fos interacting	5
<a href="#">221037</a>	JMJD1C	jumonji domain containing 1C	5
<a href="#">3423</a>	IDS	iduronate 2-sulfatase	5
<a href="#">26020</a>	LRP10	LDL receptor related protein 10	5
<a href="#">91748</a>	ELMSAN1	ELM2 and Myb/SANT domain containing 1	5
<a href="#">51177</a>	PLEKHO1	pleckstrin homology domain containing O1	5
<a href="#">4736</a>	RPL10A	ribosomal protein L10a	5
<a href="#">23262</a>	PIP5K2	diphosphoinositol pentakisphosphate kinase 2	5
<a href="#">22980</a>	TCF25	transcription factor 25	5
<a href="#">118924</a>	FRA10AC1	fragile site, folic acid type, rare, fra(10)(q23.3) or fra(10)(q24.2) candidate 1	5
<a href="#">23461</a>	ABCA5	ATP binding cassette subfamily A member 5	5
<a href="#">57189</a>	KIAA1147	KIAA1147	5
<a href="#">8085</a>	KMT2D	lysine methyltransferase 2D	5
<a href="#">26235</a>	FBXL4	F-box and leucine rich repeat protein 4	5
<a href="#">23162</a>	MAPK8IP3	mitogen-activated protein kinase 8 interacting protein 3	5
<a href="#">23067</a>	SETD1B	SET domain containing 1B	5
<a href="#">200539</a>	ANKRD23	ankyrin repeat domain 23	5
<a href="#">23315</a>	SLC9A8	solute carrier family 9 member A8	5
<a href="#">55125</a>	CEP192	centrosomal protein 192	5
<a href="#">489</a>	ATP2A3	ATPase sarcoplasmic/endoplasmic reticulum Ca <sup>2+</sup> transporting 3	5
<a href="#">83931</a>	STK40	serine/threonine kinase 40	5
<a href="#">730094</a>	C16orf52	chromosome 16 open reading frame 52	5
<a href="#">4899</a>	NRF1	nuclear respiratory factor 1	5
<a href="#">50832</a>	TAS2R4	taste 2 receptor member 4	5
<a href="#">26190</a>	FBXW2	F-box and WD repeat domain containing 2	5
<a href="#">55827</a>	DCAF6	DDB1 and CUL4 associated factor 6	5
<a href="#">27030</a>	MLH3	mutL homolog 3	5
<a href="#">7620</a>	ZNF69	zinc finger protein 69	5
<a href="#">126069</a>	ZNF491	zinc finger protein 491	5
<a href="#">221496</a>	LEMD2	LEM domain containing 2	5
<a href="#">55454</a>	CSGALNACT2	chondroitin sulfate N-acetylgalactosaminyltransferase 2	5
<a href="#">85377</a>	MICAL1	MICAL like 1	5
<a href="#">80208</a>	SPG11	spastic paraplegia 11 (autosomal recessive)	5
<a href="#">57614</a>	KIAA1468	KIAA1468	5
<a href="#">25836</a>	NIPBL	NIPBL, cohesin loading factor	5
<a href="#">54799</a>	MBTD1	mbt domain containing 1	5
<a href="#">10009</a>	ZBTB33	zinc finger and BTB domain containing 33	5
<a href="#">54681</a>	P4HTM	prolyl 4-hydroxylase, transmembrane	5
<a href="#">55139</a>	ANKZF1	ankyrin repeat and zinc finger domain containing 1	5
<a href="#">81932</a>	HDHD3	haloacid dehalogenase like hydrolase domain containing 3	5
<a href="#">8924</a>	HERC2	HECT and RLD domain containing E3 ubiquitin protein ligase 2	5
<a href="#">26260</a>	FBXO25	F-box protein 25	5
<a href="#">51755</a>	CDK12	cyclin dependent kinase 12	5
<a href="#">9205</a>	ZMYM5	zinc finger MYM-type containing 5	5
<a href="#">257218</a>	SHPRH	SNF2 histone linker PHD RING helicase	5
<a href="#">7073</a>	TIAL1	TIA1 cytotoxic granule associated RNA binding protein like 1	5
<a href="#">57148</a>	RALGAPB	Ral GTPase activating protein non-catalytic beta subunit	5

<a href="#">3213</a>	HOXB3	homeobox B3	5
<a href="#">23637</a>	RABGAP1	RAB GTPase activating protein 1	5
<a href="#">339345</a>	NANOS2	nanos C2HC-type zinc finger 2	5
<a href="#">100507424</a>	LOC100507424	uncharacterized LOC100507424	5
<a href="#">642819</a>	ZNF487	zinc finger protein 487	5
<a href="#">8419</a>	BFSP2	beaded filament structural protein 2	5
<a href="#">1185</a>	CLCN6	chloride voltage-gated channel 6	5
<a href="#">84527</a>	ZNF559	zinc finger protein 559	5
<a href="#">388564</a>	TMEM238	transmembrane protein 238	5
<a href="#">51105</a>	PHF20L1	PHD finger protein 20-like 1	5
<a href="#">317662</a>	FAM149B1	family with sequence similarity 149 member B1	5
<a href="#">8481</a>	OFD1	OFD1, centriole and centriolar satellite protein	5
<a href="#">89857</a>	KLHL6	kelch like family member 6	5
<a href="#">27125</a>	AFF4	AF4/FMR2 family member 4	5
<a href="#">7464</a>	CORO2A	coronin 2A	5
<a href="#">51304</a>	ZDHHC3	zinc finger DHHC-type containing 3	5
<a href="#">57690</a>	TNRC6C	trinucleotide repeat containing 6C	5
<a href="#">83692</a>	CD99L2	CD99 molecule like 2	5
<a href="#">50488</a>	MINK1	misshapen like kinase 1	5
<a href="#">55054</a>	ATG16L1	autophagy related 16 like 1	5
<a href="#">55683</a>	KANSL3	KAT8 regulatory NSL complex subunit 3	5
<a href="#">5991</a>	RFX3	regulatory factor X3	5
<a href="#">3570</a>	IL6R	interleukin 6 receptor	5
<a href="#">54</a>	ACP5	acid phosphatase 5, tartrate resistant	5
<a href="#">160851</a>	DGKH	diacylglycerol kinase eta	5
<a href="#">84914</a>	ZNF587	zinc finger protein 587	5
<a href="#">22933</a>	SIRT2	sirtuin 2	5
<a href="#">652968</a>	GATSL3	GATS protein like 3	5
<a href="#">196403</a>	DTX3	deltex E3 ubiquitin ligase 3	5
<a href="#">51191</a>	HERC5	HECT and RLD domain containing E3 ubiquitin protein ligase 5	5
<a href="#">57498</a>	KIDINS220	kinase D-interacting substrate 220kDa	5
<a href="#">1389</a>	CREBL2	cAMP responsive element binding protein like 2	5
<a href="#">9980</a>	DOPEY2	dopey family member 2	5
<a href="#">8543</a>	LMO4	LIM domain only 4	5
<a href="#">91782</a>	CHMP7	charged multivesicular body protein 7	5
<a href="#">5530</a>	PPP3CA	protein phosphatase 3 catalytic subunit alpha	5
<a href="#">9847</a>	C2CD5	C2 calcium dependent domain containing 5	5
<a href="#">149041</a>	RC3H1	ring finger and CCCH-type domains 1	5
<a href="#">5025</a>	P2RX4	purinergic receptor P2X 4	5
<a href="#">29068</a>	ZBTB44	zinc finger and BTB domain containing 44	5
<a href="#">10585</a>	POMT1	protein O-mannosyltransferase 1	5
<a href="#">3140</a>	MR1	major histocompatibility complex, class I-related	5
<a href="#">8556</a>	CDC14A	cell division cycle 14A	5
<a href="#">54981</a>	NMRK1	nicotinamide riboside kinase 1	5
<a href="#">117584</a>	RFFL	ring finger and FYVE like domain containing E3 ubiquitin protein ligase	5
<a href="#">841</a>	CASP8	caspase 8	5
<a href="#">1387</a>	CREBBP	CREB binding protein	5
<a href="#">10347</a>	ABCA7	ATP binding cassette subfamily A member 7	5
<a href="#">4820</a>	NKTR	natural killer cell triggering receptor	5
<a href="#">2323</a>	FLT3LG	fms related tyrosine kinase 3 ligand	5
<a href="#">274</a>	BIN1	bridging integrator 1	5
<a href="#">80830</a>	APOL6	apolipoprotein L6	5
<a href="#">54904</a>	WHSC1L1	Wolf-Hirschhorn syndrome candidate 1-like 1	5
<a href="#">6314</a>	ATXN7	ataxin 7	5
<a href="#">8861</a>	LDB1	LIM domain binding 1	5
<a href="#">5829</a>	PXN	paxillin	5
<a href="#">58485</a>	TRAPPC1	trafficking protein particle complex 1	5
<a href="#">10044</a>	SH2D3C	SH2 domain containing 3C	5
<a href="#">143098</a>	MPP7	membrane palmitoylated protein 7	5
<a href="#">11123</a>	RCAN3	RCAN family member 3	5
<a href="#">4046</a>	LSP1	lymphocyte-specific protein 1	5
<a href="#">6404</a>	SELPLG	selectin P ligand	5
<a href="#">51585</a>	PCF11	PCF11 cleavage and polyadenylation factor subunit	5
<a href="#">3338</a>	DNAJC4	DnaJ heat shock protein family (Hsp40) member C4	5
<a href="#">123036</a>	TC2N	tandem C2 domains, nuclear	5

<a href="#">53822</a>	FXYD7	FXYD domain containing ion transport regulator 7	5
<a href="#">51411</a>	BIN2	bridging integrator 2	5
<a href="#">79932</a>	KIAA0319L	KIAA0319 like	5
<a href="#">25939</a>	SAMHD1	SAM and HD domain containing deoxynucleoside triphosphate triphosphohydrolase 1	5
<a href="#">11342</a>	RNF13	ring finger protein 13	5
<a href="#">53346</a>	TM6SF1	transmembrane 6 superfamily member 1	5
<a href="#">10559</a>	SLC35A1	solute carrier family 35 member A1	5
<a href="#">900</a>	CCNG1	cyclin G1	5
<a href="#">84851</a>	TRIM52	tripartite motif containing 52	5
<a href="#">84958</a>	SYTL1	synaptotagmin like 1	5
<a href="#">9840</a>	TESPA1	thymocyte expressed, positive selection associated 1	5
<a href="#">4050</a>	LTB	lymphotoxin beta	5
<a href="#">150365</a>	MEI1	meiotic double-stranded break formation protein 1	5
<a href="#">54847</a>	SIDT1	SID1 transmembrane family member 1	5
<a href="#">11010</a>	GLIPR1	GLI pathogenesis related 1	5
<a href="#">284129</a>	SLC26A11	solute carrier family 26 member 11	5
<a href="#">837</a>	CASP4	caspase 4	5
<a href="#">54622</a>	ARL15	ADP ribosylation factor like GTPase 15	5
<a href="#">5527</a>	PPP2R5C	protein phosphatase 2 regulatory subunit B'gamma	5
<a href="#">91523</a>	PCED1B	PC-esterase domain containing 1B	5
<a href="#">3135</a>	HLA-G	major histocompatibility complex, class I, G	5
<a href="#">91689</a>	SMDT1	single-pass membrane protein with aspartate rich tail 1	5
<a href="#">23125</a>	CAMTA2	calmodulin binding transcription activator 2	5
<a href="#">5920</a>	RARRES3	retinoic acid receptor responder 3	5
<a href="#">3594</a>	IL12RB1	interleukin 12 receptor subunit beta 1	5
<a href="#">360</a>	AQP3	aquaporin 3 (Gill blood group)	5
<a href="#">158830</a>	CXorf65	chromosome X open reading frame 65	5
<a href="#">3955</a>	LFNG	LFNG O-fucosylpeptide 3-beta-N-acetylglucosaminyltransferase	5
<a href="#">57489</a>	ODF2L	outer dense fiber of sperm tails 2 like	5
<a href="#">7567</a>	ZNF19	zinc finger protein 19	5
<a href="#">219402</a>	MTIF3	mitochondrial translational initiation factor 3	5
<a href="#">123688</a>	HYKK	hydroxylysine kinase	5
<a href="#">5588</a>	PRKCQ	protein kinase C theta	5
<a href="#">6275</a>	S100A4	S100 calcium binding protein A4	5
<a href="#">118429</a>	ANTXR2	anthrax toxin receptor 2	5
<a href="#">177</a>	AGER	advanced glycosylation end-product specific receptor	5
<a href="#">10365</a>	KLF2	Kruppel like factor 2	5
<a href="#">51274</a>	KLF3	Kruppel like factor 3	5
<a href="#">2537</a>	IFI6	interferon alpha inducible protein 6	5
<a href="#">4063</a>	LY9	lymphocyte antigen 9	5
<a href="#">201595</a>	STT3B	STT3B, catalytic subunit of the oligosaccharyltransferase complex	5
<a href="#">151613</a>	TTC14	tetratricopeptide repeat domain 14	5
<a href="#">9725</a>	TMEM63A	transmembrane protein 63A	5
<a href="#">51586</a>	MED15	mediator complex subunit 15	5
<a href="#">23515</a>	MORC3	MORC family CW-type zinc finger 3	5
<a href="#">23046</a>	KIF21B	kinesin family member 21B	5
<a href="#">2145</a>	EZH1	enhancer of zeste 1 polycomb repressive complex 2 subunit	5
<a href="#">5175</a>	PECAM1	platelet and endothelial cell adhesion molecule 1	5
<a href="#">387357</a>	THEMIS	thymocyte selection associated	5
<a href="#">29767</a>	TMOD2	tropomodulin 2	5
<a href="#">4599</a>	MX1	MX dynamin like GTPase 1	5
<a href="#">916</a>	CD3E	CD3e molecule	5
<a href="#">972</a>	CD74	CD74 molecule	5
<a href="#">220972</a>	MARCH8	membrane associated ring-CH-type finger 8	5
<a href="#">115209</a>	OMA1	OMA1 zinc metallopeptidase	5
<a href="#">84456</a>	L3MBTL3	l(3)mbt-like 3 (Drosophila)	5
<a href="#">4179</a>	CD46	CD46 molecule	5
<a href="#">51816</a>	CECR1	cat eye syndrome chromosome region, candidate 1	5
<a href="#">51019</a>	CCDC53	coiled-coil domain containing 53	5
<a href="#">196513</a>	DCP1B	decapping mRNA 1B	5
<a href="#">23593</a>	HEBP2	heme binding protein 2	5
<a href="#">10627</a>	MYL12A	myosin light chain 12A	5
<a href="#">55217</a>	TMLHE	trimethyllysine hydroxylase, epsilon	5
<a href="#">55281</a>	TMEM140	transmembrane protein 140	5
<a href="#">5371</a>	PML	promyelocytic leukemia	5

<a href="#">55906</a>	ZC4H2	zinc finger C4H2-type containing	5
<a href="#">9113</a>	LATS1	large tumor suppressor kinase 1	5
<a href="#">4494</a>	MT1F	metallothionein 1F	5
<a href="#">389289</a>	ANXA2R	annexin A2 receptor	5
<a href="#">22884</a>	WDR37	WD repeat domain 37	5
<a href="#">6430</a>	SRSF5	serine and arginine rich splicing factor 5	5
<a href="#">317649</a>	EIF4E3	eukaryotic translation initiation factor 4E family member 3	5
<a href="#">94241</a>	TP53INP1	tumor protein p53 inducible nuclear protein 1	5
<a href="#">93550</a>	ZFAND4	zinc finger AN1-type containing 4	5
<a href="#">10397</a>	NDRG1	N-myc downstream regulated 1	5
<a href="#">8916</a>	HERC3	HECT and RLD domain containing E3 ubiquitin protein ligase 3	5
<a href="#">6903</a>	TBCC	tubulin folding cofactor C	5
<a href="#">301</a>	ANXA1	annexin A1	5
<a href="#">79726</a>	WDR59	WD repeat domain 59	5
<a href="#">159090</a>	FAM122B	family with sequence similarity 122B	5
<a href="#">284004</a>	HEXDC	hexosaminidase D	5
<a href="#">10781</a>	ZNF266	zinc finger protein 266	5
<a href="#">151636</a>	DTX3L	deltex E3 ubiquitin ligase 3L	5
<a href="#">7507</a>	XPA	XPA, DNA damage recognition and repair factor	5
<a href="#">23287</a>	AGTPBP1	ATP/GTP binding protein 1	5
<a href="#">146198</a>	ZFP90	ZFP90 zinc finger protein	5
<a href="#">405</a>	ARNT	aryl hydrocarbon receptor nuclear translocator	5
<a href="#">9867</a>	PJA2	praja ring finger ubiquitin ligase 2	5
<a href="#">79364</a>	ZXDC	ZXD family zinc finger C	5
<a href="#">158219</a>	TTC39B	tetratricopeptide repeat domain 39B	5
<a href="#">221178</a>	SPATA13	spermatogenesis associated 13	5
<a href="#">128346</a>	C1orf162	chromosome 1 open reading frame 162	5
<a href="#">9267</a>	CYTH1	cytohesin 1	5
<a href="#">3431</a>	SP110	SP110 nuclear body protein	5
<a href="#">157378</a>	TMEM65	transmembrane protein 65	5
<a href="#">152926</a>	PPM1K	protein phosphatase, Mg <sup>2+</sup> /Mn <sup>2+</sup> dependent 1K	5
<a href="#">5775</a>	PTPN4	protein tyrosine phosphatase, non-receptor type 4	5
<a href="#">92797</a>	HELB	DNA helicase B	5
<a href="#">81704</a>	DOCK8	dedicator of cytokinesis 8	5
<a href="#">29909</a>	GPR171	G protein-coupled receptor 171	5
<a href="#">147138</a>	TMC8	transmembrane channel like 8	5
<a href="#">10466</a>	COG5	component of oligomeric golgi complex 5	5
<a href="#">6667</a>	SP1	Sp1 transcription factor	5
<a href="#">8554</a>	PIAS1	protein inhibitor of activated STAT 1	5
<a href="#">757</a>	TMEM50B	transmembrane protein 50B	5
<a href="#">55825</a>	PECR	peroxisomal trans-2-enoyl-CoA reductase	5
<a href="#">493</a>	ATP2B4	ATPase plasma membrane Ca <sup>2+</sup> transporting 4	5
<a href="#">3655</a>	ITGA6	integrin subunit alpha 6	5
<a href="#">5292</a>	PIM1	Pim-1 proto-oncogene, serine/threonine kinase	5
<a href="#">9922</a>	IQSEC1	IQ motif and Sec7 domain 1	5
<a href="#">152006</a>	RNF38	ring finger protein 38	5
<a href="#">163049</a>	ZNF791	zinc finger protein 791	5
<a href="#">4214</a>	MAP3K1	mitogen-activated protein kinase kinase kinase 1	5
<a href="#">23032</a>	USP33	ubiquitin specific peptidase 33	5
<a href="#">23033</a>	DOPEY1	dopey family member 1	5
<a href="#">56605</a>	ERO1B	endoplasmic reticulum oxidoreductase 1 beta	5
<a href="#">27430</a>	MAT2B	methionine adenosyltransferase 2B	5
<a href="#">388558</a>	ZNF808	zinc finger protein 808	5
<a href="#">8867</a>	SYNJ1	synaptojanin 1	5
<a href="#">84719</a>	LINC00260	long intergenic non-protein coding RNA 260	5
<a href="#">51667</a>	NUB1	negative regulator of ubiquitin like proteins 1	5
<a href="#">79770</a>	TXNDC15	thioredoxin domain containing 15	5
<a href="#">834</a>	CASP1	caspase 1	5
<a href="#">64598</a>	MOSPD3	motile sperm domain containing 3	5
<a href="#">3106</a>	HLA-B	major histocompatibility complex, class I, B	5
<a href="#">3669</a>	ISG20	interferon stimulated exonuclease gene 20	5
<a href="#">554223</a>	LOC554223	histocompatibility antigen-related	5
<a href="#">4077</a>	NBR1	NBR1, autophagy cargo receptor	5
<a href="#">10379</a>	IRF9	interferon regulatory factor 9	5
<a href="#">64844</a>	MARCH7	membrane associated ring-CH-type finger 7	5

<a href="#">3841</a>	KPNA5	karyopherin subunit alpha 5	5
<a href="#">8644</a>	AKR1C3	aldo-keto reductase family 1 member C3	5
<a href="#">54464</a>	XRN1	5'-3' exoribonuclease 1	5
<a href="#">80342</a>	TRAF3IP3	TRAF3 interacting protein 3	5
<a href="#">5335</a>	PLCG1	phospholipase C gamma 1	5
<a href="#">55007</a>	FAM118A	family with sequence similarity 118 member A	5
<a href="#">26999</a>	CYFIP2	cytoplasmic FMR1 interacting protein 2	5
<a href="#">51478</a>	HSD17B7	hydroxysteroid 17-beta dehydrogenase 7	5
<a href="#">91351</a>	DDX60L	DEAD-box helicase 60-like	5
<a href="#">9445</a>	ITM2B	integral membrane protein 2B	5
<a href="#">388552</a>	BLOC1S3	biogenesis of lysosomal organelles complex 1 subunit 3	5
<a href="#">54809</a>	SAMD9	sterile alpha motif domain containing 9	5
<a href="#">219285</a>	SAMD9L	sterile alpha motif domain containing 9 like	5
<a href="#">80833</a>	APOL3	apolipoprotein L3	5
<a href="#">3581</a>	IL9R	interleukin 9 receptor	5
<a href="#">1519</a>	CTSO	cathepsin O	5
<a href="#">63935</a>	PCIF1	PDX1 C-terminal inhibiting factor 1	5
<a href="#">8615</a>	USO1	USO1 vesicle transport factor	5
<a href="#">1655</a>	DDX5	DEAD-box helicase 5	5
<a href="#">28968</a>	SLC6A16	solute carrier family 6 member 16	5
<a href="#">6786</a>	STIM1	stromal interaction molecule 1	5
<a href="#">57018</a>	CCNL1	cyclin L1	5
<a href="#">10455</a>	ECI2	enoyl-CoA delta isomerase 2	5
<a href="#">7597</a>	ZBTB25	zinc finger and BTB domain containing 25	5
<a href="#">114769</a>	CARD16	caspase recruitment domain family member 16	5
<a href="#">54891</a>	INO80D	INO80 complex subunit D	5
<a href="#">8875</a>	VNN2	vanin 2	5
<a href="#">162394</a>	SLFN5	schlafen family member 5	5
<a href="#">55196</a>	KIAA1551	KIAA1551	5
<a href="#">397</a>	ARHGDIB	Rho GDP dissociation inhibitor beta	5
<a href="#">91526</a>	ANKRD44	ankyrin repeat domain 44	5
<a href="#">5934</a>	RBL2	RB transcriptional corepressor like 2	5
<a href="#">23586</a>	DDX58	DEXD/H-box helicase 58	5
<a href="#">1388</a>	ATF6B	activating transcription factor 6 beta	5
<a href="#">10521</a>	DDX17	DEAD-box helicase 17	5
<a href="#">64771</a>	C6orf106	chromosome 6 open reading frame 106	5
<a href="#">89848</a>	FCHSD1	FCH and double SH3 domains 1	5
<a href="#">9881</a>	TRANK1	tetratricopeptide repeat and ankyrin repeat containing 1	5
<a href="#">3275</a>	PRMT2	protein arginine methyltransferase 2	5
<a href="#">7059</a>	THBS3	thrombospondin 3	5
<a href="#">9976</a>	CLEC2B	C-type lectin domain family 2 member B	5
<a href="#">832</a>	CAPZB	capping actin protein of muscle Z-line beta subunit	5
<a href="#">79903</a>	NAA60	N(alpha)-acetyltransferase 60, NatF catalytic subunit	5
<a href="#">57097</a>	PARP11	poly(ADP-ribose) polymerase family member 11	5
<a href="#">51000</a>	SLC35B3	solute carrier family 35 member B3	5
<a href="#">2633</a>	GBP1	guanylate binding protein 1	5
<a href="#">112849</a>	L3HYPDH	trans-L-3-hydroxyproline dehydratase	5
<a href="#">901</a>	CCNG2	cyclin G2	5
<a href="#">1429</a>	CRYZ	crystallin zeta	5
<a href="#">3105</a>	HLA-A	major histocompatibility complex, class I, A	5
<a href="#">94240</a>	EPST11	epithelial stromal interaction 1 (breast)	5
<a href="#">3134</a>	HLA-F	major histocompatibility complex, class I, F	5
<a href="#">11119</a>	BTN3A1	butyrophilin subfamily 3 member A1	5
<a href="#">3139</a>	HLA-L	major histocompatibility complex, class I, L (pseudogene)	5
<a href="#">10161</a>	LPAR6	lysophosphatidic acid receptor 6	5
<a href="#">10154</a>	PLXNC1	plexin C1	5
<a href="#">79603</a>	CERS4	ceramide synthase 4	5
<a href="#">84173</a>	ELMOD3	ELMO domain containing 3	5
<a href="#">55837</a>	EAPP	E2F associated phosphoprotein	5
<a href="#">3107</a>	HLA-C	major histocompatibility complex, class I, C	5
<a href="#">222223</a>	KIAA1324L	KIAA1324 like	5
<a href="#">49855</a>	SCAPER	S-phase cyclin A associated protein in the ER	5
<a href="#">64386</a>	MMP25	matrix metalloproteinase 25	5
<a href="#">7538</a>	ZFP36	ZFP36 ring finger protein	5
<a href="#">55437</a>	STRADB	STE20-related kinase adaptor beta	5

<a href="#">80298</a>	MTERF2	mitochondrial transcription termination factor 2	5
<a href="#">1025</a>	CDK9	cyclin dependent kinase 9	5
<a href="#">4943</a>	TBC1D25	TBC1 domain family member 25	5
<a href="#">90826</a>	PRMT9	protein arginine methyltransferase 9	5
<a href="#">54497</a>	HEATR5B	HEAT repeat containing 5B	5
<a href="#">22878</a>	TRAPPC8	trafficking protein particle complex 8	5
<a href="#">1513</a>	CTSK	cathepsin K	5
<a href="#">79654</a>	HECTD3	HECT domain E3 ubiquitin protein ligase 3	5
<a href="#">8450</a>	CUL4B	cullin 4B	5
<a href="#">27241</a>	BBS9	Bardet-Biedl syndrome 9	5
<a href="#">23060</a>	ZNF609	zinc finger protein 609	5
<a href="#">8816</a>	DCAF5	DDB1 and CUL4 associated factor 5	5
<a href="#">84727</a>	SPSB2	sp1A/ryanodine receptor domain and SOCS box containing 2	5
<a href="#">51379</a>	CRLF3	cytokine receptor like factor 3	5
<a href="#">3071</a>	NCKAP1L	NCK associated protein 1 like	5
<a href="#">55288</a>	RHOT1	ras homolog family member T1	5
<a href="#">10444</a>	ZER1	zyg-11 related cell cycle regulator	5
<a href="#">842</a>	CASP9	caspase 9	5
<a href="#">92</a>	ACVR2A	activin A receptor type 2A	5
<a href="#">4690</a>	NCK1	NCK adaptor protein 1	5
<a href="#">84307</a>	ZNF397	zinc finger protein 397	5
<a href="#">7716</a>	VEZF1	vascular endothelial zinc finger 1	5
<a href="#">64091</a>	POPDC2	popeye domain containing 2	5
<a href="#">8934</a>	RAB29	RAB29, member RAS oncogene family	5
<a href="#">55283</a>	MCOLN3	mucolipin 3	5
<a href="#">23588</a>	KLHDC2	kelch domain containing 2	5
<a href="#">4600</a>	MX2	MX dynamin like GTPase 2	5
<a href="#">9860</a>	LRIG2	leucine rich repeats and immunoglobulin like domains 2	5
<a href="#">7852</a>	CXCR4	C-X-C motif chemokine receptor 4	5
<a href="#">64109</a>	CRLF2	cytokine receptor-like factor 2	5
<a href="#">9528</a>	TMEM59	transmembrane protein 59	5
<a href="#">2319</a>	FLOT2	flotillin 2	5
<a href="#">686</a>	BTD	biotinidase	5
<a href="#">7046</a>	TGFBR1	transforming growth factor beta receptor 1	5
<a href="#">3903</a>	LAIR1	leukocyte associated immunoglobulin like receptor 1	5
<a href="#">22821</a>	RASA3	RAS p21 protein activator 3	5
<a href="#">55070</a>	DET1	de-etiolated homolog 1 (Arabidopsis)	5
<a href="#">57184</a>	FAM219B	family with sequence similarity 219 member B	5
<a href="#">153241</a>	CEP120	centrosomal protein 120	5
<a href="#">25809</a>	TTLL1	tubulin tyrosine ligase like 1	5
<a href="#">55762</a>	ZNF701	zinc finger protein 701	5
<a href="#">22841</a>	RAB11FIP2	RAB11 family interacting protein 2	5
<a href="#">119504</a>	ANAPC16	anaphase promoting complex subunit 16	5
<a href="#">286530</a>	P2RY8	purinergic receptor P2Y8	5
<a href="#">55080</a>	TAPBPL	TAP binding protein like	5
<a href="#">6746</a>	SSR2	signal sequence receptor subunit 2	5
<a href="#">54103</a>	GSAP	gamma-secretase activating protein	5
<a href="#">79991</a>	OBFC1	oligonucleotide/oligosaccharide binding fold containing 1	5
<a href="#">51170</a>	HSD17B11	hydroxysteroid 17-beta dehydrogenase 11	5
<a href="#">79758</a>	DHRS12	dehydrogenase/reductase 12	5
<a href="#">283897</a>	C16orf54	chromosome 16 open reading frame 54	5
<a href="#">29978</a>	UBQLN2	ubiquilin 2	5
<a href="#">139716</a>	GAB3	GRB2 associated binding protein 3	5
<a href="#">6619</a>	SNAPC3	small nuclear RNA activating complex polypeptide 3	5
<a href="#">53347</a>	UBASH3A	ubiquitin associated and SH3 domain containing A	5
<a href="#">57763</a>	ANKRA2	ankyrin repeat family A member 2	5
<a href="#">6095</a>	RORA	RAR related orphan receptor A	5
<a href="#">6777</a>	STAT5B	signal transducer and activator of transcription 5B	5
<a href="#">7182</a>	NR2C2	nuclear receptor subfamily 2 group C member 2	5
<a href="#">85007</a>	PHYKPL	5-phosphohydroxy-L-lysine phospho-lyase	5
<a href="#">84765</a>	ZNF577	zinc finger protein 577	5
<a href="#">10144</a>	FAM13A	family with sequence similarity 13 member A	5
<a href="#">1154</a>	CISH	cytokine inducible SH2 containing protein	5
<a href="#">64418</a>	TMEM168	transmembrane protein 168	5
<a href="#">4689</a>	NCF4	neutrophil cytosolic factor 4	5

<a href="#">1520</a>	CTSS	cathepsin S	5
<a href="#">59307</a>	SIGIRR	single Ig and TIR domain containing	5
<a href="#">11329</a>	STK38	serine/threonine kinase 38	5
<a href="#">54440</a>	SASH3	SAM and SH3 domain containing 3	5
<a href="#">545</a>	ATR	ATR serine/threonine kinase	5
<a href="#">7693</a>	ZNF134	zinc finger protein 134	5
<a href="#">10947</a>	AP3M2	adaptor related protein complex 3 mu 2 subunit	5
<a href="#">728743</a>	LOC728743	zinc finger protein pseudogene	5
<a href="#">7311</a>	UBA52	ubiquitin A-52 residue ribosomal protein fusion product 1	5
<a href="#">55357</a>	TBC1D2	TBC1 domain family member 2	5
<a href="#">6468</a>	FBXW4	F-box and WD repeat domain containing 4	5
<a href="#">8698</a>	S1PR4	sphingosine-1-phosphate receptor 4	5
<a href="#">204851</a>	HIPK1	homeodomain interacting protein kinase 1	5
<a href="#">54778</a>	RNF111	ring finger protein 111	5
<a href="#">84532</a>	ACSS1	acyl-CoA synthetase short-chain family member 1	5
<a href="#">80335</a>	WDR82	WD repeat domain 82	5
<a href="#">9905</a>	SGSM2	small G protein signaling modulator 2	5
<a href="#">4242</a>	MFNG	MFNG O-fucosylpeptide 3-beta-N-acetylglucosaminyltransferase	5
<a href="#">388324</a>	INCA1	inhibitor of CDK, cyclin A1 interacting protein 1	5
<a href="#">57567</a>	ZNF319	zinc finger protein 319	5
<a href="#">25992</a>	SNED1	sushi, nidogen and EGF like domains 1	5
<a href="#">79717</a>	PPCS	phosphopantothenoylcysteine synthetase	5
<a href="#">51091</a>	SEPSECS	Sep (O-phosphoserine) tRNA:Sec (selenocysteine) tRNA synthase	5
<a href="#">55846</a>	ITFG2	integrin alpha FG-GAP repeat containing 2	5
<a href="#">64174</a>	DPEP2	dipeptidase 2	5
<a href="#">9834</a>	FAM30A	family with sequence similarity 30, member A	5
<a href="#">24142</a>	NAT6	N-acetyltransferase 6	5
<a href="#">57181</a>	SLC39A10	solute carrier family 39 member 10	5
<a href="#">374986</a>	MIGA1	mitoguardin 1	5
<a href="#">847</a>	CAT	catalase	5
<a href="#">9842</a>	PLEKHM1	pleckstrin homology and RUN domain containing M1	5
<a href="#">66035</a>	SLC2A11	solute carrier family 2 member 11	5
<a href="#">6872</a>	TAF1	TATA-box binding protein associated factor 1	5
<a href="#">80230</a>	RUFY1	RUN and FYVE domain containing 1	5
<a href="#">259290</a>	TAS2R31	taste 2 receptor member 31	5
<a href="#">51291</a>	GMIP	GEM interacting protein	5
<a href="#">25900</a>	IFFO1	intermediate filament family orphan 1	5
<a href="#">9736</a>	USP34	ubiquitin specific peptidase 34	5
<a href="#">5494</a>	PPM1A	protein phosphatase, Mg2+/Mn2+ dependent 1A	5
<a href="#">83874</a>	TBC1D10A	TBC1 domain family member 10A	5
<a href="#">5287</a>	PIK3C2B	phosphatidylinositol-4-phosphate 3-kinase catalytic subunit type 2 beta	5
<a href="#">53373</a>	TPCN1	two pore segment channel 1	5
<a href="#">96459</a>	FNIP1	folliculin interacting protein 1	5
<a href="#">51592</a>	TRIM33	tripartite motif containing 33	5
<a href="#">8720</a>	MBTPS1	membrane bound transcription factor peptidase, site 1	5
<a href="#">23167</a>	EFR3A	EFR3 homolog A	5
<a href="#">221491</a>	C6orf1	chromosome 6 open reading frame 1	5
<a href="#">887</a>	CCKBR	cholecystokinin B receptor	5
<a href="#">1509</a>	CTSD	cathepsin D	5
<a href="#">283149</a>	BCL9L	B-cell CLL/lymphoma 9-like	5
<a href="#">6239</a>	RREB1	ras responsive element binding protein 1	5
<a href="#">6497</a>	SKI	SKI proto-oncogene	5
<a href="#">7745</a>	ZKSCAN8	zinc finger with KRAB and SCAN domains 8	5
<a href="#">23389</a>	MED13L	mediator complex subunit 13 like	5
<a href="#">8289</a>	ARID1A	AT-rich interaction domain 1A	5
<a href="#">324</a>	APC	APC, WNT signaling pathway regulator	5
<a href="#">4750</a>	NEK1	NIMA related kinase 1	5
<a href="#">89845</a>	ABCC10	ATP binding cassette subfamily C member 10	5
<a href="#">5058</a>	PAK1	p21 (RAC1) activated kinase 1	5
<a href="#">4680</a>	CEACAM6	carcinoembryonic antigen related cell adhesion molecule 6	5
<a href="#">1773</a>	DNASE1	deoxyribonuclease 1	5
<a href="#">64219</a>	PJA1	praja ring finger ubiquitin ligase 1	5
<a href="#">23339</a>	VPS39	VPS39, HOPS complex subunit	5
<a href="#">57610</a>	RANBP10	RAN binding protein 10	5
<a href="#">80124</a>	VCPIP1	valosin containing protein interacting protein 1	5



<a href="#">84142</a>	FAM175A	family with sequence similarity 175 member A	5
<a href="#">23102</a>	TBC1D2B	TBC1 domain family member 2B	5
<a href="#">50717</a>	DCAF8	DDB1 and CUL4 associated factor 8	5
<a href="#">84447</a>	SYVN1	synoviolin 1	5
<a href="#">84897</a>	TBRG1	transforming growth factor beta regulator 1	5
<a href="#">9451</a>	EIF2AK3	eukaryotic translation initiation factor 2 alpha kinase 3	5
<a href="#">8621</a>	CDK13	cyclin dependent kinase 13	5
<a href="#">155435</a>	RBM33	RNA binding motif protein 33	5
<a href="#">359845</a>	RFLNB	refilin B	5
<a href="#">8535</a>	CBX4	chromobox 4	5
<a href="#">79037</a>	PVRIG	poliovirus receptor related immunoglobulin domain containing	5
<a href="#">80169</a>	CTC1	CTS telomere maintenance complex component 1	5
<a href="#">3678</a>	ITGA5	integrin subunit alpha 5	5
<a href="#">256987</a>	SERINC5	serine incorporator 5	5
<a href="#">54462</a>	CCSER2	coiled-coil serine rich protein 2	5
<a href="#">8527</a>	DGKD	diacylglycerol kinase delta	5
<a href="#">9149</a>	DYRK1B	dual specificity tyrosine phosphorylation regulated kinase 1B	5
<a href="#">246744</a>	STH	saitohin	5
<a href="#">162515</a>	SLC16A11	solute carrier family 16 member 11	5
<a href="#">348378</a>	FAM159A	family with sequence similarity 159 member A	5
<a href="#">92840</a>	REEP6	receptor accessory protein 6	5
<a href="#">8665</a>	EIF3F	eukaryotic translation initiation factor 3 subunit F	5
<a href="#">393</a>	ARHGAP4	Rho GTPase activating protein 4	5
<a href="#">84836</a>	ABHD14B	abhydrolase domain containing 14B	5
<a href="#">9788</a>	MTSS1	MTSS1, I-BAR domain containing	5
<a href="#">113878</a>	DTX2	deltex E3 ubiquitin ligase 2	5
<a href="#">51092</a>	SIDT2	SID1 transmembrane family member 2	5
<a href="#">23295</a>	MGRN1	mahogunin ring finger 1	5
<a href="#">401944</a>	LDLRAD2	low density lipoprotein receptor class A domain containing 2	5
<a href="#">11322</a>	TMC6	transmembrane channel like 6	5
<a href="#">168620</a>	BHLHA15	basic helix-loop-helix family member a15	5
<a href="#">84270</a>	CARD19	caspase recruitment domain family member 19	5
<a href="#">151176</a>	ERFE	erythroferrone	5
<a href="#">84266</a>	ALKBH7	alkB homolog 7	5
<a href="#">7508</a>	XPC	XPC complex subunit, DNA damage recognition and repair factor	5
<a href="#">199746</a>	U2AF1L4	U2 small nuclear RNA auxiliary factor 1 like 4	5
<a href="#">10043</a>	TOM1	target of myb1 membrane trafficking protein	5
<a href="#">4696</a>	NDUFA3	NADH:ubiquinone oxidoreductase subunit A3	5
<a href="#">9498</a>	SLC4A8	solute carrier family 4 member 8	5
<a href="#">3611</a>	ILK	integrin linked kinase	5
<a href="#">6160</a>	RPL31	ribosomal protein L31	5
<a href="#">283450</a>	HECTD4	HECT domain E3 ubiquitin protein ligase 4	5
<a href="#">105371397</a>	LOC105371397	uncharacterized LOC105371397	5
<a href="#">197358</a>	NLRC3	NLR family CARD domain containing 3	5
<a href="#">6122</a>	RPL3	ribosomal protein L3	5
<a href="#">30815</a>	ST6GALNAC6	ST6 N-acetylgalactosaminide alpha-2,6-sialyltransferase 6	5
<a href="#">9022</a>	CLIC3	chloride intracellular channel 3	5
<a href="#">56260</a>	C8orf44	chromosome 8 open reading frame 44	5
<a href="#">5663</a>	PSEN1	presenilin 1	5
<a href="#">23177</a>	CEP68	centrosomal protein 68	5
<a href="#">9397</a>	NMT2	N-myristoyltransferase 2	5
<a href="#">10868</a>	USP20	ubiquitin specific peptidase 20	5
<a href="#">1107</a>	CHD3	chromodomain helicase DNA binding protein 3	5
<a href="#">26112</a>	CCDC69	coiled-coil domain containing 69	5
<a href="#">115992</a>	RNF166	ring finger protein 166	5
<a href="#">51393</a>	TRPV2	transient receptor potential cation channel subfamily V member 2	5
<a href="#">55229</a>	PANK4	pantothenate kinase 4	5
<a href="#">113791</a>	PIK3IP1	phosphoinositide-3-kinase interacting protein 1	5
<a href="#">92017</a>	SNX29	sorting nexin 29	5
<a href="#">80095</a>	ZNF606	zinc finger protein 606	5
<a href="#">51646</a>	YPEL5	yippee like 5	5
<a href="#">3476</a>	IGBP1	immunoglobulin (CD79A) binding protein 1	5
<a href="#">22997</a>	IGSF9B	immunoglobulin superfamily member 9B	5
<a href="#">5790</a>	PTPRCAP	protein tyrosine phosphatase, receptor type C associated protein	5
<a href="#">951</a>	CD37	CD37 molecule	5

<a href="#">22861</a>	NLRP1	NLR family pyrin domain containing 1	5
<a href="#">170622</a>	COMMD6	COMM domain containing 6	5
<a href="#">2124</a>	EVI2B	ecotropic viral integration site 2B	5
<a href="#">10346</a>	TRIM22	tripartite motif containing 22	5
<a href="#">151556</a>	GPR155	G protein-coupled receptor 155	5
<a href="#">50515</a>	CHST11	carbohydrate sulfotransferase 11	5
<a href="#">472</a>	ATM	ATM serine/threonine kinase	5
<a href="#">7626</a>	ZNF75D	zinc finger protein 75D	5
<a href="#">7294</a>	TXK	TXK tyrosine kinase	5
<a href="#">10957</a>	PNRC1	proline rich nuclear receptor coactivator 1	5
<a href="#">339210</a>	C17orf67	chromosome 17 open reading frame 67	5
<a href="#">51466</a>	EVL	Enah/Vasp-like	5
<a href="#">9750</a>	FAM65B	family with sequence similarity 65 member B	5
<a href="#">5140</a>	PDE3B	phosphodiesterase 3B	5
<a href="#">4300</a>	MLLT3	MLLT3, super elongation complex subunit	5
<a href="#">5252</a>	PHF1	PHD finger protein 1	5
<a href="#">5330</a>	PLCB2	phospholipase C beta 2	5
<a href="#">4118</a>	MAL	mal, T-cell differentiation protein	5
<a href="#">63940</a>	GPSM3	G-protein signaling modulator 3	5
<a href="#">645432</a>	ARRDC5	arrestin domain containing 5	5
<a href="#">3932</a>	LCK	LCK proto-oncogene, Src family tyrosine kinase	5
<a href="#">255394</a>	TCP11L2	t-complex 11 like 2	5
<a href="#">80853</a>	KDM7A	lysine demethylase 7A	5
<a href="#">140688</a>	NOL4L	nucleolar protein 4 like	5
<a href="#">55643</a>	BTBD2	BTB domain containing 2	5
<a href="#">6277</a>	S100A6	S100 calcium binding protein A6	5
<a href="#">5800</a>	PTPRO	protein tyrosine phosphatase, receptor type O	5
<a href="#">126375</a>	ZNF792	zinc finger protein 792	5
<a href="#">64761</a>	PARP12	poly(ADP-ribose) polymerase family member 12	5
<a href="#">51614</a>	ERGIC3	ERGIC and golgi 3	5
<a href="#">90592</a>	ZNF700	zinc finger protein 700	5
<a href="#">66008</a>	TRAK2	trafficking kinesin protein 2	5
<a href="#">64332</a>	NFKBIZ	NFKB inhibitor zeta	5
<a href="#">9710</a>	KIAA0355	KIAA0355	5
<a href="#">54665</a>	RSBN1	round spermatid basic protein 1	5
<a href="#">9382</a>	COG1	component of oligomeric golgi complex 1	5
<a href="#">22839</a>	DLGAP4	DLG associated protein 4	5
<a href="#">11035</a>	RIPK3	receptor interacting serine/threonine kinase 3	5
<a href="#">57639</a>	CCDC146	coiled-coil domain containing 146	5
<a href="#">23152</a>	CIC	capicua transcriptional repressor	5
<a href="#">113177</a>	IZUMO4	IZUMO family member 4	5
<a href="#">55568</a>	GALNT10	polypeptide N-acetylgalactosaminyltransferase 10	5
<a href="#">84101</a>	USP44	ubiquitin specific peptidase 44	5
<a href="#">85378</a>	TUBGCP6	tubulin gamma complex associated protein 6	5
<a href="#">10673</a>	TNFSF13B	tumor necrosis factor superfamily member 13b	5
<a href="#">54674</a>	LRRN3	leucine rich repeat neuronal 3	5
<a href="#">6282</a>	S100A11	S100 calcium binding protein A11	5
<a href="#">53827</a>	FXYD5	FXYD domain containing ion transport regulator 5	5
<a href="#">79864</a>	C11orf63	chromosome 11 open reading frame 63	5
<a href="#">57060</a>	PCBP4	poly(rC) binding protein 4	5
<a href="#">3566</a>	IL4R	interleukin 4 receptor	5
<a href="#">50650</a>	ARHGEF3	Rho guanine nucleotide exchange factor 3	5
<a href="#">64393</a>	ZMAT3	zinc finger matrin-type 3	5
<a href="#">5147</a>	PDE6D	phosphodiesterase 6D	5
<a href="#">491</a>	ATP2B2	ATPase plasma membrane Ca2+ transporting 2	5
<a href="#">129293</a>	TRABD2A	TraB domain containing 2A	5
<a href="#">284802</a>	FRG1BP	FSDH region gene 1 family member B, pseudogene	5
<a href="#">3702</a>	ITK	IL2 inducible T-cell kinase	5
<a href="#">23253</a>	ANKRD12	ankyrin repeat domain 12	5
<a href="#">5788</a>	PTPRC	protein tyrosine phosphatase, receptor type C	5
<a href="#">23471</a>	TRAM1	translocation associated membrane protein 1	5
<a href="#">84910</a>	TMEM87B	transmembrane protein 87B	5
<a href="#">50848</a>	F11R	F11 receptor	5
<a href="#">4154</a>	MBNL1	muscleblind like splicing regulator 1	5
<a href="#">9595</a>	CYTIP	cytohesin 1 interacting protein	5

<a href="#">57591</a>	MKL1	megakaryoblastic leukemia (translocation) 1	5
<a href="#">1386</a>	ATF2	activating transcription factor 2	5
<a href="#">5324</a>	PLAG1	PLAG1 zinc finger	5
<a href="#">9781</a>	RNF144A	ring finger protein 144A	5
<a href="#">284058</a>	KANSL1	KAT8 regulatory NSL complex subunit 1	5
<a href="#">9663</a>	LPIN2	lipin 2	5
<a href="#">23522</a>	KAT6B	lysine acetyltransferase 6B	5
<a href="#">814</a>	CAMK4	calcium/calmodulin dependent protein kinase IV	5
<a href="#">406</a>	ARNTL	aryl hydrocarbon receptor nuclear translocator like	5
<a href="#">143686</a>	SESN3	sestrin 3	5
<a href="#">10225</a>	CD96	CD96 molecule	5
<a href="#">9262</a>	STK17B	serine/threonine kinase 17b	5
<a href="#">6206</a>	RPS12	ribosomal protein S12	5
<a href="#">3937</a>	LCP2	lymphocyte cytosolic protein 2	5
<a href="#">8031</a>	NCOA4	nuclear receptor coactivator 4	5
<a href="#">10142</a>	AKAP9	A-kinase anchoring protein 9	5
<a href="#">22848</a>	AAK1	AP2 associated kinase 1	5
<a href="#">129607</a>	CMPK2	cytidine/uridine monophosphate kinase 2	5
<a href="#">113612</a>	CYP2U1	cytochrome P450 family 2 subfamily U member 1	5
<a href="#">1508</a>	CTSBB	cathepsin B	5
<a href="#">18</a>	ABAT	4-aminobutyrate aminotransferase	5
<a href="#">391191</a>	OR2AK2	olfactory receptor family 2 subfamily AK member 2	5
<a href="#">55664</a>	CDC37L1	cell division cycle 37 like 1	5
<a href="#">5334</a>	PLCL1	phospholipase C like 1	5
<a href="#">6940</a>	ZNF354A	zinc finger protein 354A	5
<a href="#">116986</a>	AGAP2	ArfGAP with GTPase domain, ankyrin repeat and PH domain 2	5
<a href="#">3588</a>	IL10RB	interleukin 10 receptor subunit beta	5
<a href="#">23064</a>	SETX	senataxin	5
<a href="#">2771</a>	GNAI2	G protein subunit alpha i2	5
<a href="#">26054</a>	SENP6	SUMO1/sentrin specific peptidase 6	5
<a href="#">408</a>	ARRB1	arrestin beta 1	5
<a href="#">9770</a>	RASSF2	Ras association domain family member 2	5
<a href="#">54832</a>	VPS13C	vacuolar protein sorting 13 homolog C	5
<a href="#">149951</a>	COMMMD7	COMM domain containing 7	5
<a href="#">54469</a>	ZFAND6	zinc finger AN1-type containing 6	5
<a href="#">7188</a>	TRAF5	TNF receptor associated factor 5	5
<a href="#">399</a>	RHOH	ras homolog family member H	5
<a href="#">60313</a>	GPBP1L1	GC-rich promoter binding protein 1 like 1	5
<a href="#">4478</a>	MSN	moesin	5
<a href="#">91543</a>	RSAD2	radical S-adenosyl methionine domain containing 2	5
<a href="#">115362</a>	GBP5	guanylate binding protein 5	5
<a href="#">29761</a>	USP25	ubiquitin specific peptidase 25	5
<a href="#">399665</a>	FAM102A	family with sequence similarity 102 member A	5
<a href="#">80709</a>	AKNA	AT-hook transcription factor	5
<a href="#">3603</a>	IL16	interleukin 16	5
<a href="#">64098</a>	PARVG	parvin gamma	5
<a href="#">64839</a>	FBXL17	F-box and leucine rich repeat protein 17	5
<a href="#">9263</a>	STK17A	serine/threonine kinase 17a	5
<a href="#">51176</a>	LEF1	lymphoid enhancer binding factor 1	5
<a href="#">9641</a>	IKBKE	inhibitor of kappa light polypeptide gene enhancer in B-cells, kinase epsilon	5
<a href="#">27250</a>	PDCD4	programmed cell death 4 (neoplastic transformation inhibitor)	5
<a href="#">9402</a>	GRAP2	GRB2-related adaptor protein 2	5
<a href="#">197131</a>	UBR1	ubiquitin protein ligase E3 component n-recognin 1	5
<a href="#">26137</a>	ZBTB20	zinc finger and BTB domain containing 20	5
<a href="#">51201</a>	ZDHHC2	zinc finger DHHC-type containing 2	5
<a href="#">23112</a>	TNRC6B	trinucleotide repeat containing 6B	5
<a href="#">11046</a>	SLC35D2	solute carrier family 35 member D2	5
<a href="#">9665</a>	KIAA0430	KIAA0430	5
<a href="#">151050</a>	KANSL1L	KAT8 regulatory NSL complex subunit 1 like	5
<a href="#">7805</a>	LAPTM5	lysosomal protein transmembrane 5	5
<a href="#">115294</a>	PCMTD1	protein-L-isoadipate (D-aspartate) O-methyltransferase domain containing 1	5
<a href="#">10443</a>	N4BP2L2	NEDD4 binding protein 2 like 2	5
<a href="#">89846</a>	FGD3	FYVE, RhoGEF and PH domain containing 3	5
<a href="#">822</a>	CAPG	capping actin protein, gelsolin like	5
<a href="#">83605</a>	CCM2	CCM2 scaffolding protein	5

<a href="#">83719</a>	YPEL3	yippee like 3	5
<a href="#">157697</a>	ERICH1	glutamate rich 1	5
<a href="#">79090</a>	TRAPPC6A	trafficking protein particle complex 6A	5
<a href="#">60682</a>	SMAP1	small ArfGAP 1	5
<a href="#">57561</a>	ARRDC3	arrestin domain containing 3	5
<a href="#">23348</a>	DOCK9	dedicator of cytokinesis 9	5
<a href="#">6904</a>	TBCD	tubulin folding cofactor D	5
<a href="#">375056</a>	MIA3	MIA family member 3, ER export factor	5
<a href="#">9877</a>	ZC3H11A	zinc finger CCCH-type containing 11A	5
<a href="#">10608</a>	MXD4	MAX dimerization protein 4	5
<a href="#">112936</a>	VPS26B	VPS26, retromer complex component B	5
<a href="#">92241</a>	RCSD1	RCSD domain containing 1	5
<a href="#">6709</a>	SPTAN1	spectrin alpha, non-erythrocytic 1	5
<a href="#">643866</a>	CBLN3	cerebellin 3 precursor	5
<a href="#">9857</a>	CEP350	centrosomal protein 350	5
<a href="#">57134</a>	MAN1C1	mannosidase alpha class 1C member 1	5
<a href="#">81688</a>	C6orf62	chromosome 6 open reading frame 62	5
<a href="#">9459</a>	ARHGEF6	Rac/Cdc42 guanine nucleotide exchange factor 6	5
<a href="#">2113</a>	ETS1	ETS proto-oncogene 1, transcription factor	5
<a href="#">23118</a>	TAB2	TGF-beta activated kinase 1/MAP3K7 binding protein 2	5
<a href="#">7267</a>	TTC3	tetratricopeptide repeat domain 3	5
<a href="#">54014</a>	BRWD1	bromodomain and WD repeat domain containing 1	5
<a href="#">157680</a>	VPS13B	vacuolar protein sorting 13 homolog B	5
<a href="#">4863</a>	NPAT	nuclear protein, coactivator of histone transcription	5
<a href="#">9563</a>	H6PD	hexose-6-phosphate dehydrogenase/glucose 1-dehydrogenase	5
<a href="#">4650</a>	MYO9B	myosin IXB	5
<a href="#">6655</a>	SOS2	SOS Ras/Rho guanine nucleotide exchange factor 2	5
<a href="#">7535</a>	ZAP70	zeta chain of T cell receptor associated protein kinase 70	5
<a href="#">23240</a>	KIAA0922	KIAA0922	5
<a href="#">57459</a>	GATAD2B	GATA zinc finger domain containing 2B	5
<a href="#">311</a>	ANXA11	annexin A11	5
<a href="#">54800</a>	KLHL24	kelch like family member 24	5
<a href="#">114823</a>	LENG8	leukocyte receptor cluster member 8	5
<a href="#">10659</a>	CELFB2	CUGBP, Elav-like family member 2	5
<a href="#">57551</a>	TAOK1	TAO kinase 1	5
<a href="#">9815</a>	GIT2	GIT ArfGAP 2	5
<a href="#">56261</a>	GPCPD1	glycerophosphocholine phosphodiesterase 1	5
<a href="#">50619</a>	DEF6	DEF6, guanine nucleotide exchange factor	5
<a href="#">387082</a>	SUMO4	small ubiquitin-like modifier 4	5
<a href="#">170954</a>	PPP1R18	protein phosphatase 1 regulatory subunit 18	5
<a href="#">23031</a>	MAST3	microtubule associated serine/threonine kinase 3	5
<a href="#">7764</a>	ZNF217	zinc finger protein 217	5
<a href="#">9139</a>	CBFA2T2	CBFA2/RUNX1 translocation partner 2	5
<a href="#">23508</a>	TTC9	tetratricopeptide repeat domain 9	5
<a href="#">64131</a>	XYLT1	xylosyltransferase 1	5
<a href="#">57594</a>	HOMEZ	homeobox and leucine zipper encoding	5
<a href="#">55526</a>	DHTKD1	dehydrogenase E1 and transketolase domain containing 1	5
<a href="#">57506</a>	MAVS	mitochondrial antiviral signaling protein	5
<a href="#">55780</a>	ERMARD	ER membrane associated RNA degradation	5
<a href="#">387119</a>	CEP85L	centrosomal protein 85 like	5
<a href="#">57492</a>	ARID1B	AT-rich interaction domain 1B	5
<a href="#">84726</a>	PRRC2B	proline rich coiled-coil 2B	5
<a href="#">123720</a>	WHAMM	WAS protein homolog associated with actin, golgi membranes and microtubules	5
<a href="#">9138</a>	ARHGEF1	Rho guanine nucleotide exchange factor 1	5
<a href="#">10401</a>	PIAS3	protein inhibitor of activated STAT 3	5
<a href="#">57038</a>	RARS2	arginyl-tRNA synthetase 2, mitochondrial	5
<a href="#">283219</a>	KCTD21	potassium channel tetramerization domain containing 21	5
<a href="#">103910</a>	MYL12B	myosin light chain 12B	5
<a href="#">51084</a>	CRYL1	crystallin lambda 1	5
<a href="#">79982</a>	DNAJB14	DnaJ heat shock protein family (Hsp40) member B14	5
<a href="#">90324</a>	CCDC97	coiled-coil domain containing 97	5
<a href="#">374868</a>	ATP9B	ATPase phospholipid transporting 9B (putative)	5
<a href="#">80146</a>	UXS1	UDP-glucuronate decarboxylase 1	5
<a href="#">138050</a>	HGSNAT	heparan-alpha-glucosaminide N-acetyltransferase	5
<a href="#">54467</a>	ANKIB1	ankyrin repeat and IBR domain containing 1	5

<a href="#">80232</a>	WDR26	WD repeat domain 26	5
<a href="#">1785</a>	DNM2	dynamain 2	5
<a href="#">9266</a>	CYTH2	cytohesin 2	5
<a href="#">9870</a>	AREL1	apoptosis resistant E3 ubiquitin protein ligase 1	5
<a href="#">93663</a>	ARHGAP18	Rho GTPase activating protein 18	5
<a href="#">80790</a>	CMIP	c-Maf inducing protein	5
<a href="#">752</a>	FMNL1	formin like 1	5
<a href="#">10180</a>	RBM6	RNA binding motif protein 6	5
<a href="#">23048</a>	FNBP1	formin binding protein 1	5
<a href="#">374879</a>	ZNF699	zinc finger protein 699	5
<a href="#">54838</a>	WBP1L	WW domain binding protein 1-like	5
<a href="#">167153</a>	PAPD4	poly(A) RNA polymerase D4, non-canonical	5
<a href="#">132864</a>	CPFB2	cytoplasmic polyadenylation element binding protein 2	5
<a href="#">10618</a>	TGOLN2	trans-golgi network protein 2	5
<a href="#">5978</a>	REST	RE1 silencing transcription factor	5
<a href="#">54454</a>	ATAD2B	ATPase family, AAA domain containing 2B	5
<a href="#">221322</a>	TBC1D32	TBC1 domain family member 32	5
<a href="#">107987150</a>			5
<a href="#">55716</a>	LMBR1L	limb development membrane protein 1 like	5
<a href="#">5291</a>	PIK3CB	phosphatidylinositol-4,5-bisphosphate 3-kinase catalytic subunit beta	5
<a href="#">55763</a>	EXOC1	exocyst complex component 1	5
<a href="#">83989</a>	FAM172A	family with sequence similarity 172 member A	5
<a href="#">23181</a>	DIP2A	disco interacting protein 2 homolog A	5
<a href="#">197135</a>	PATL2	PAT1 homolog 2	5
<a href="#">9813</a>	EFCAB14	EF-hand calcium binding domain 14	5
<a href="#">55073</a>	LRR37A4P	leucine rich repeat containing 37 member A4, pseudogene	5
<a href="#">83752</a>	LONP2	lon peptidase 2, peroxisomal	5
<a href="#">84181</a>	CHD6	chromodomain helicase DNA binding protein 6	5
<a href="#">29072</a>	SETD2	SET domain containing 2	5
<a href="#">8850</a>	KAT2B	lysine acetyltransferase 2B	5
<a href="#">11176</a>	BAZ2A	bromodomain adjacent to zinc finger domain 2A	5
<a href="#">27436</a>	EML4	echinoderm microtubule associated protein like 4	5
<a href="#">64224</a>	HERPUD2	HERPUD family member 2	5
<a href="#">84678</a>	KDM2B	lysine demethylase 2B	5
<a href="#">91749</a>	MFS4B	major facilitator superfamily domain containing 4B	5
<a href="#">9439</a>	MED23	mediator complex subunit 23	5
<a href="#">55761</a>	TTC17	tetratricopeptide repeat domain 17	5
<a href="#">7110</a>	TMF1	TATA element modulatory factor 1	5
<a href="#">3683</a>	ITGAL	integrin subunit alpha L	5
<a href="#">80821</a>	DDHD1	DDHD domain containing 1	5
<a href="#">51742</a>	ARID4B	AT-rich interaction domain 4B	5
<a href="#">94103</a>	ORMDL3	ORMDL sphingolipid biosynthesis regulator 3	5
<a href="#">51161</a>	C3orf18	chromosome 3 open reading frame 18	5
<a href="#">23228</a>	PLCL2	phospholipase C like 2	5
<a href="#">146057</a>	TTBK2	tau tubulin kinase 2	5
<a href="#">10260</a>	DENND4A	DENN domain containing 4A	5
<a href="#">79979</a>	TRMT2B	tRNA methyltransferase 2 homolog B	5
<a href="#">23347</a>	SMCHD1	structural maintenance of chromosomes flexible hinge domain containing 1	5
<a href="#">259293</a>	TAS2R30	taste 2 receptor member 30	5
<a href="#">7072</a>	TIA1	TIA1 cytotoxic granule associated RNA binding protein	5
<a href="#">57474</a>	ZNF490	zinc finger protein 490	5
<a href="#">79048</a>	SECISBP2	SECIS binding protein 2	5
<a href="#">23081</a>	KDM4C	lysine demethylase 4C	5
<a href="#">161176</a>	SYNE3	spectrin repeat containing nuclear envelope family member 3	5
<a href="#">5095</a>	PCCA	propionyl-CoA carboxylase alpha subunit	5
<a href="#">79618</a>	HMBOX1	homeobox containing 1	5
<a href="#">9731</a>	CEP104	centrosomal protein 104	5
<a href="#">50804</a>	MYEF2	myelin expression factor 2	5
<a href="#">64236</a>	PDLIM2	PDZ and LIM domain 2	5
<a href="#">10956</a>	OS9	OS9, endoplasmic reticulum lectin	5
<a href="#">9517</a>	SPTLC2	serine palmitoyltransferase long chain base subunit 2	5
<a href="#">5294</a>	PIK3CG	phosphatidylinositol-4,5-bisphosphate 3-kinase catalytic subunit gamma	5
<a href="#">55062</a>	WIP1	WD repeat domain, phosphoinositide interacting 1	5
<a href="#">64895</a>	PAPOLG	poly(A) polymerase gamma	5
<a href="#">55106</a>	SLFN12	schlafen family member 12	5

<a href="#">9170</a>	LPAR2	lysophosphatidic acid receptor 2	5
<a href="#">85315</a>	PAQR8	progesterin and adipoQ receptor family member 8	5
<a href="#">222484</a>	LNx2	ligand of numb-protein X 2	5
<a href="#">1739</a>	DLG1	discs large MAGUK scaffold protein 1	5
<a href="#">6480</a>	ST6GAL1	ST6 beta-galactoside alpha-2,6-sialyltransferase 1	5
<a href="#">9968</a>	MED12	mediator complex subunit 12	5
<a href="#">54625</a>	PARP14	poly(ADP-ribose) polymerase family member 14	5
<a href="#">25851</a>	TECPR1	tectonin beta-propeller repeat containing 1	5
<a href="#">55008</a>	HERC6	HECT and RLD domain containing E3 ubiquitin protein ligase family member 6	5
<a href="#">22828</a>	SCAF8	SR-related CTD associated factor 8	5
<a href="#">5862</a>	RAB2A	RAB2A, member RAS oncogene family	5
<a href="#">9525</a>	VPS4B	vacuolar protein sorting 4 homolog B	5
<a href="#">115361</a>	GBP4	guanylate binding protein 4	5
<a href="#">57020</a>	C16orf62	chromosome 16 open reading frame 62	5
<a href="#">93349</a>	SP140L	SP140 nuclear body protein like	5
<a href="#">6464</a>	SHC1	SHC adaptor protein 1	5
<a href="#">55601</a>	DDX60	DEXD/H-box helicase 60	5
<a href="#">22887</a>	FOXJ3	forkhead box J3	5
<a href="#">5870</a>	RAB6A	RAB6A, member RAS oncogene family	5
<a href="#">30061</a>	SLC40A1	solute carrier family 40 member 1	5
<a href="#">201799</a>	TMEM154	transmembrane protein 154	5
<a href="#">80063</a>	ATF7IP2	activating transcription factor 7 interacting protein 2	5
<a href="#">149086</a>	LINC01225	long intergenic non-protein coding RNA 1225	5
<a href="#">4033</a>	LRMP	lymphoid restricted membrane protein	5
<a href="#">55770</a>	EXOC2	exocyst complex component 2	5
<a href="#">3575</a>	IL7R	interleukin 7 receptor	5
<a href="#">7494</a>	XBP1	X-box binding protein 1	5
<a href="#">10320</a>	IKZF1	IKAROS family zinc finger 1	5
<a href="#">51149</a>	C5orf45	chromosome 5 open reading frame 45	5
<a href="#">7562</a>	ZNF708	zinc finger protein 708	5
<a href="#">80012</a>	PHC3	polyhomeotic homolog 3	5
<a href="#">637</a>	BID	BH3 interacting domain death agonist	5
<a href="#">3059</a>	HCLS1	hematopoietic cell-specific Lyn substrate 1	5
<a href="#">80008</a>	TMEM156	transmembrane protein 156	5
<a href="#">79893</a>	GGNBP2	gametogenetin binding protein 2	5
<a href="#">11016</a>	ATF7	activating transcription factor 7	5
<a href="#">80167</a>	ABHD18	abhydrolase domain containing 18	5
<a href="#">1385</a>	CREB1	cAMP responsive element binding protein 1	5
<a href="#">64864</a>	RFX7	regulatory factor X7	5
<a href="#">114908</a>	TMEM123	transmembrane protein 123	5
<a href="#">56990</a>	CDC42SE2	CDC42 small effector 2	5
<a href="#">84923</a>	FAM104A	family with sequence similarity 104 member A	5
<a href="#">10097</a>	ACTR2	ARP2 actin related protein 2 homolog	5
<a href="#">223082</a>	ZNRF2	zinc and ring finger 2	5
<a href="#">80705</a>	TSGA10	testis specific 10	5
<a href="#">79970</a>	ZNF767P	zinc finger family member 767, pseudogene	5
<a href="#">22882</a>	ZHX2	zinc fingers and homeoboxes 2	5
<a href="#">83548</a>	COG3	component of oligomeric golgi complex 3	5
<a href="#">4891</a>	SLC11A2	solute carrier family 11 member 2	5
<a href="#">56650</a>	CLDN1	claudin domain containing 1	5
<a href="#">9235</a>	IL32	interleukin 32	5
<a href="#">23533</a>	PIK3R5	phosphoinositide-3-kinase regulatory subunit 5	5
<a href="#">8674</a>	VAMP4	vesicle associated membrane protein 4	5
<a href="#">55303</a>	GIMAP4	GTPase, IMAP family member 4	5
<a href="#">3676</a>	ITGA4	integrin subunit alpha 4	5
<a href="#">1048</a>	CEACAM5	carcinoembryonic antigen related cell adhesion molecule 5	5
<a href="#">6251</a>	RSU1	Ras suppressor protein 1	5
<a href="#">596</a>	BCL2	BCL2, apoptosis regulator	5
<a href="#">137872</a>	ADHFE1	alcohol dehydrogenase, iron containing 1	5
<a href="#">120</a>	ADD3	adducin 3	5
<a href="#">7454</a>	WAS	Wiskott-Aldrich syndrome	5
<a href="#">283537</a>	SLC46A3	solute carrier family 46 member 3	5
<a href="#">79830</a>	ZMYM1	zinc finger MYM-type containing 1	5
<a href="#">81558</a>	FAM117A	family with sequence similarity 117 member A	5
<a href="#">22890</a>	ZBTB1	zinc finger and BTB domain containing 1	5

<a href="#">122773</a>	KLHDC1	kelch domain containing 1	5
<a href="#">54893</a>	MTMR10	myotubularin related protein 10	5
<a href="#">10068</a>	IL18BP	interleukin 18 binding protein	5
<a href="#">90634</a>	N4BP2L1	NEDD4 binding protein 2 like 1	5
<a href="#">50618</a>	ITSN2	intersectin 2	5
<a href="#">1060</a>	CENPC	centromere protein C	5
<a href="#">130872</a>	AHSA2	AHA1, activator of heat shock 90kDa protein ATPase homolog 2 (yeast)	5
<a href="#">146691</a>	TOM1L2	target of myb1 like 2 membrane trafficking protein	5
<a href="#">2595</a>	GANC	glucosidase alpha, neutral C	5
<a href="#">116068</a>	LYSMD3	LysM domain containing 3	5
<a href="#">54557</a>	SGTB	small glutamine rich tetratricopeptide repeat containing beta	5
<a href="#">98</a>	ACYP2	acylphosphatase 2	5
<a href="#">2946</a>	GSTM2	glutathione S-transferase mu 2	5
<a href="#">9786</a>	KIAA0586	KIAA0586	5
<a href="#">196441</a>	ZFC3H1	zinc finger C3H1-type containing	5
<a href="#">5567</a>	PRKACB	protein kinase cAMP-activated catalytic subunit beta	5
<a href="#">205717</a>	USF3	upstream transcription factor family member 3	5
<a href="#">65981</a>	CAPRIN2	caprin family member 2	5
<a href="#">25956</a>	SEC31B	SEC31 homolog B, COPII coat complex component	5
<a href="#">401494</a>	HACD4	3-hydroxyacyl-CoA dehydratase 4	5
<a href="#">25988</a>	HINFP	histone H4 transcription factor	5
<a href="#">57035</a>	RSRP1	arginine and serine rich protein 1	5
<a href="#">133418</a>	EMB	embigin	5
<a href="#">6793</a>	STK10	serine/threonine kinase 10	5
<a href="#">10905</a>	MAN1A2	mannosidase alpha class 1A member 2	5
<a href="#">92822</a>	ZNF276	zinc finger protein 276	5
<a href="#">9910</a>	RABGAP1L	RAB GTPase activating protein 1 like	5
<a href="#">94039</a>	ZNF101	zinc finger protein 101	5
<a href="#">84450</a>	ZNF512	zinc finger protein 512	5
<a href="#">2734</a>	GLG1	golgi glycoprotein 1	5
<a href="#">26091</a>	HERC4	HECT and RLD domain containing E3 ubiquitin protein ligase 4	5
<a href="#">101928361</a>	LOC101928361	uncharacterized LOC101928361	5
<a href="#">23043</a>	TNIK	TRAF2 and NCK interacting kinase	5
<a href="#">147657</a>	ZNF480	zinc finger protein 480	5
<a href="#">64921</a>	CASD1	CAS1 domain containing 1	5
<a href="#">867</a>	CBL	Cbl proto-oncogene	5
<a href="#">55904</a>	KMT2E	lysine methyltransferase 2E	5
<a href="#">55680</a>	RUFY2	RUN and FYVE domain containing 2	5
<a href="#">23469</a>	PHF3	PHD finger protein 3	5
<a href="#">1803</a>	DPP4	dipeptidyl peptidase 4	5
<a href="#">128077</a>	LIX1L	limb and CNS expressed 1 like	5
<a href="#">5305</a>	PIP4K2A	phosphatidylinositol-5-phosphate 4-kinase type 2 alpha	5
<a href="#">192669</a>	AGO3	argonate 3, RISC catalytic component	5
<a href="#">80055</a>	PGAP1	post-GPI attachment to proteins 1	5
<a href="#">440193</a>	CCDC88C	coiled-coil domain containing 88C	5
<a href="#">79956</a>	ERMP1	endoplasmic reticulum metalloproteinase 1	5
<a href="#">440345</a>	NPIP4	nuclear pore complex interacting protein family member B4	5
<a href="#">23224</a>	SYNE2	spectrin repeat containing nuclear envelope protein 2	5
<a href="#">11276</a>	SYNRG	synergin gamma	5
<a href="#">114659</a>	LRRC37B	leucine rich repeat containing 37B	5
<a href="#">225</a>	ABCD2	ATP binding cassette subfamily D member 2	5
<a href="#">55823</a>	VPS11	VPS11, CORVET/HOPS core subunit	5
<a href="#">55843</a>	ARHGAP15	Rho GTPase activating protein 15	5
<a href="#">342371</a>	ATXN1L	ataxin 1 like	5
<a href="#">55754</a>	TMEM30A	transmembrane protein 30A	5
<a href="#">83464</a>	APH1B	aph-1 homolog B, gamma-secretase subunit	5
<a href="#">641339</a>	ZNF674	zinc finger protein 674	5
<a href="#">23360</a>	FNBP4	formin binding protein 4	5
<a href="#">57186</a>	RALGAPA2	Ral GTPase activating protein catalytic alpha subunit 2	5
<a href="#">410</a>	ARSA	arylsulfatase A	5
<a href="#">27244</a>	SESN1	sestrin 1	5
<a href="#">376940</a>	ZC3H6	zinc finger CCCH-type containing 6	5
<a href="#">22869</a>	ZNF510	zinc finger protein 510	5
<a href="#">9988</a>	DMTF1	cyclin D binding myb like transcription factor 1	5
<a href="#">81550</a>	TDRD3	tudor domain containing 3	5

<a href="#">6672</a>	SP100	SP100 nuclear antigen	5
<a href="#">114803</a>	MYSM1	Myb like, SWIRM and MPN domains 1	5
<a href="#">7431</a>	VIM	vimentin	5
<a href="#">57577</a>	CCDC191	coiled-coil domain containing 191	5
<a href="#">7318</a>	UBA7	ubiquitin like modifier activating enzyme 7	5
<a href="#">254065</a>	BRWD3	bromodomain and WD repeat domain containing 3	5
<a href="#">23200</a>	ATP11B	ATPase phospholipid transporting 11B (putative)	5
<a href="#">55297</a>	CCDC91	coiled-coil domain containing 91	5
<a href="#">64167</a>	ERAP2	endoplasmic reticulum aminopeptidase 2	5
<a href="#">9759</a>	HDAC4	histone deacetylase 4	5
<a href="#">100507419</a>	MMP25-AS1	MMP25 antisense RNA 1	5
<a href="#">388585</a>	HES5	hes family bHLH transcription factor 5	5
<a href="#">51621</a>	KLF13	Kruppel like factor 13	5
<a href="#">150864</a>	FAM117B	family with sequence similarity 117 member B	5
<a href="#">51316</a>	PLAC8	placenta specific 8	5
<a href="#">57179</a>	KIAA1191	KIAA1191	5
<a href="#">163050</a>	ZNF564	zinc finger protein 564	5
<a href="#">2073</a>	ERCC5	ERCC excision repair 5, endonuclease	5
<a href="#">81669</a>	CCNL2	cyclin L2	5
<a href="#">5880</a>	RAC2	ras-related C3 botulinum toxin substrate 2 (rho family, small GTP binding protein Rac2)	5
<a href="#">10207</a>	PATJ	PATJ, crumbs cell polarity complex component	5
<a href="#">1265</a>	CNN2	calponin 2	5
<a href="#">634</a>	CEACAM1	carcinoembryonic antigen related cell adhesion molecule 1	5
<a href="#">10123</a>	ARL4C	ADP ribosylation factor like GTPase 4C	5
<a href="#">121506</a>	ERP27	endoplasmic reticulum protein 27	5
<a href="#">6451</a>	SH3BGRL	SH3 domain binding glutamate rich protein like	5
<a href="#">84166</a>	NLRCS	NLR family CARD domain containing 5	5
<a href="#">30011</a>	SH3KBP1	SH3 domain containing kinase binding protein 1	5
<a href="#">23499</a>	MACF1	microtubule-actin crosslinking factor 1	5
<a href="#">2186</a>	BPTF	bromodomain PHD finger transcription factor	5
<a href="#">1997</a>	ELF1	E74 like ETS transcription factor 1	5
<a href="#">6654</a>	SOS1	SOS Ras/Rac guanine nucleotide exchange factor 1	5
<a href="#">107984315</a>			5
<a href="#">1200</a>	TPP1	tripeptidyl peptidase 1	5
<a href="#">80212</a>	CCDC92	coiled-coil domain containing 92	5
<a href="#">1486</a>	CTBS	chitobiase	5
<a href="#">27128</a>	CYTH4	cytohesin 4	5
<a href="#">11261</a>	CHP1	calcineurin like EF-hand protein 1	5
<a href="#">54518</a>	APBB1IP	amyloid beta precursor protein binding family B member 1 interacting protein	5
<a href="#">1606</a>	DGKA	diacylglycerol kinase alpha	5
<a href="#">153222</a>	CREBRF	CREB3 regulatory factor	5
<a href="#">80024</a>	SLC8B1	solute carrier family 8 member B1	5
<a href="#">2635</a>	GBP3	guanylate binding protein 3	5
<a href="#">64784</a>	CRTC3	CREB regulated transcription coactivator 3	5
<a href="#">79813</a>	EHMT1	euchromatic histone lysine methyltransferase 1	5
<a href="#">8906</a>	AP1G2	adaptor related protein complex 1 gamma 2 subunit	5
<a href="#">155006</a>	TMEM213	transmembrane protein 213	5
<a href="#">442582</a>	STAG3L2	stromal antigen 3-like 2 (pseudogene)	5
<a href="#">1182</a>	CLCN3	chloride voltage-gated channel 3	5
<a href="#">51735</a>	RAPGEF6	Rap guanine nucleotide exchange factor 6	5
<a href="#">92106</a>	OXNAD1	oxidoreductase NAD binding domain containing 1	5
<a href="#">100420110</a>	LOC100420110	SCY1 like pseudokinase 2 pseudogene	5
<a href="#">6164</a>	RPL34	ribosomal protein L34	5
<a href="#">4354</a>	MPP1	membrane palmitoylated protein 1	5
<a href="#">1487</a>	CTBP1	C-terminal binding protein 1	5
<a href="#">58487</a>	CREBZF	CREB/ATF bZIP transcription factor	5
<a href="#">4026</a>	LPP	LIM domain containing preferred translocation partner in lipoma	5
<a href="#">26259</a>	FBXW8	F-box and WD repeat domain containing 8	5
<a href="#">51773</a>	RSF1	remodeling and spacing factor 1	5
<a href="#">6641</a>	SNTB1	syntrophin beta 1	5
<a href="#">79161</a>	TMEM243	transmembrane protein 243	5
<a href="#">5586</a>	PKN2	protein kinase N2	5
<a href="#">64766</a>	S100PBP	S100P binding protein	5
<a href="#">3460</a>	IFNGR2	interferon gamma receptor 2 (interferon gamma transducer 1)	5

<a href="#">7273</a>	TTN	titin	5
<a href="#">8835</a>	SOCS2	suppressor of cytokine signaling 2	5
<a href="#">11320</a>	MGAT4A	mannosyl (alpha-1,3-)-glycoprotein beta-1,4-N-acetylglucosaminyltransferase, isozyme A	5
<a href="#">54861</a>	SNRK	SNF related kinase	5
<a href="#">4012</a>	LNPEP	leucyl and cystinyl aminopeptidase	5
<a href="#">128611</a>	ZNF831	zinc finger protein 831	5
<a href="#">7456</a>	WIPF1	WAS/WASL interacting protein family member 1	5
<a href="#">9830</a>	TRIM14	tripartite motif containing 14	5
<a href="#">50852</a>	TRAT1	T cell receptor associated transmembrane adaptor 1	5
<a href="#">22990</a>	PCNX1	pecanex homolog 1 (Drosophila)	5
<a href="#">11083</a>	DIDO1	death inducer-obliterator 1	5
<a href="#">1106</a>	CHD2	chromodomain helicase DNA binding protein 2	5
<a href="#">7644</a>	ZNF91	zinc finger protein 91	5
<a href="#">1540</a>	CYLD	CYLD lysine 63 deubiquitinase	5
<a href="#">643641</a>	ZNF862	zinc finger protein 862	5
<a href="#">10106</a>	CTDSP2	CTD small phosphatase 2	5
<a href="#">154881</a>	KCTD7	potassium channel tetramerization domain containing 7	5
<a href="#">23164</a>	MPRIIP	myosin phosphatase Rho interacting protein	5
<a href="#">4299</a>	AFF1	AF4/FMR2 family member 1	5
<a href="#">93611</a>	FBXO44	F-box protein 44	5
<a href="#">7402</a>	UTRN	utrophin	5
<a href="#">56204</a>	FAM214A	family with sequence similarity 214 member A	5
<a href="#">6844</a>	VAMP2	vesicle associated membrane protein 2	5
<a href="#">9960</a>	USP3	ubiquitin specific peptidase 3	5
<a href="#">4297</a>	KMT2A	lysine methyltransferase 2A	5
<a href="#">56829</a>	ZC3HAV1	zinc finger CCCH-type containing, antiviral 1	5
<a href="#">139818</a>	DOCK11	dedicator of cytokinesis 11	5
<a href="#">25777</a>	SUN2	Sad1 and UNC84 domain containing 2	5
<a href="#">9744</a>	ACAP1	ArfGAP with coiled-coil, ankyrin repeat and PH domains 1	5
<a href="#">23054</a>	NCOA6	nuclear receptor coactivator 6	5
<a href="#">84162</a>	KIAA1109	KIAA1109	5
<a href="#">23341</a>	DNAJC16	DnaJ heat shock protein family (Hsp40) member C16	5
<a href="#">23324</a>	MAN2B2	mannosidase alpha class 2B member 2	5
<a href="#">6711</a>	SPTBN1	spectrin beta, non-erythrocytic 1	5
<a href="#">165631</a>	PARP15	poly(ADP-ribose) polymerase family member 15	5
<a href="#">5786</a>	PTPRA	protein tyrosine phosphatase, receptor type A	5
<a href="#">9535</a>	GMFG	glia maturation factor gamma	5
<a href="#">256643</a>	CXorf23	chromosome X open reading frame 23	5
<a href="#">55268</a>	ECHDC2	enoyl-CoA hydratase domain containing 2	5
<a href="#">22838</a>	RNF44	ring finger protein 44	5
<a href="#">55870</a>	ASH1L	ASH1 like histone lysine methyltransferase	5
<a href="#">64780</a>	MICAL1	microtubule associated monooxygenase, calponin and LIM domain containing 1	5
<a href="#">84460</a>	ZMAT1	zinc finger matrix-type 1	5
<a href="#">200576</a>	PIKFYVE	phosphoinositide kinase, FYVE-type zinc finger containing	5
<a href="#">58508</a>	KMT2C	lysine methyltransferase 2C	5
<a href="#">8897</a>	MTMR3	myotubularin related protein 3	5
<a href="#">2033</a>	EP300	E1A binding protein p300	5
<a href="#">80351</a>	TNKS2	tankyrase 2	5
<a href="#">9648</a>	GCC2	GRIP and coiled-coil domain containing 2	5
<a href="#">163131</a>	ZNF780B	zinc finger protein 780B	5
<a href="#">23335</a>	WDR7	WD repeat domain 7	5
<a href="#">55599</a>	RNPC3	RNA binding region (RNP1, RRM) containing 3	5
<a href="#">3716</a>	JAK1	Janus kinase 1	5
<a href="#">493753</a>	COA5	cytochrome c oxidase assembly factor 5	5
<a href="#">55824</a>	PAG1	phosphoprotein membrane anchor with glycosphingolipid microdomains 1	5
<a href="#">114801</a>	TMEM200A	transmembrane protein 200A	5
<a href="#">64750</a>	SMURF2	SMAD specific E3 ubiquitin protein ligase 2	5
<a href="#">57337</a>	SENP7	SUMO1/sentrin specific peptidase 7	5
<a href="#">831</a>	CAST	calpastatin	5
<a href="#">257106</a>	ARHGAP30	Rho GTPase activating protein 30	5
<a href="#">84945</a>	ABHD13	abhydrolase domain containing 13	5
<a href="#">129285</a>	PPP1R21	protein phosphatase 1 regulatory subunit 21	5
<a href="#">100507217</a>	LINC01578	long intergenic non-protein coding RNA 1578	5
<a href="#">285025</a>	CCDC141	coiled-coil domain containing 141	5



<a href="#">338657</a>	CCDC84	coiled-coil domain containing 84	5
<a href="#">84899</a>	TMTC4	transmembrane and tetratricopeptide repeat containing 4	5
<a href="#">23355</a>	VPS8	VPS8, CORVET complex subunit	5
<a href="#">23175</a>	LPIN1	lipin 1	5
<a href="#">27334</a>	P2RY10	purinergic receptor P2Y10	5
<a href="#">11067</a>	C10orf10	chromosome 10 open reading frame 10	5
<a href="#">26959</a>	HBP1	HMG-box transcription factor 1	5
<a href="#">168537</a>	GIMAP7	GTPase, IMAP family member 7	5
<a href="#">10550</a>	ARL6IP5	ADP ribosylation factor like GTPase 6 interacting protein 5	5
<a href="#">2005</a>	ELK4	ELK4, ETS transcription factor	5
<a href="#">253260</a>	RICTOR	RPTOR independent companion of MTOR complex 2	5
<a href="#">2533</a>	FYB	FYN binding protein	5
<a href="#">1806</a>	DPYD	dihydropyrimidine dehydrogenase	5
<a href="#">55249</a>	YY1AP1	YY1 associated protein 1	5
<a href="#">55197</a>	RPRD1A	regulation of nuclear pre-mRNA domain containing 1A	5
<a href="#">7586</a>	ZKSCAN1	zinc finger with KRAB and SCAN domains 1	5
<a href="#">23086</a>	EXPH5	exophilin 5	5
<a href="#">10006</a>	ABI1	abl interactor 1	5
<a href="#">10241</a>	CALCOCO2	calcium binding and coiled-coil domain 2	5
<a href="#">5926</a>	ARID4A	AT-rich interaction domain 4A	5
<a href="#">5583</a>	PRKCH	protein kinase C eta	5
<a href="#">7769</a>	ZNF226	zinc finger protein 226	5
<a href="#">84223</a>	IQCG	IQ motif containing G	5
<a href="#">284323</a>	ZNF780A	zinc finger protein 780A	5
<a href="#">23476</a>	BRD4	bromodomain containing 4	5
<a href="#">9611</a>	NCOR1	nuclear receptor corepressor 1	5
<a href="#">51306</a>	FAM13B	family with sequence similarity 13 member B	5
<a href="#">9802</a>	DAZAP2	DAZ associated protein 2	5
<a href="#">5782</a>	PTPN12	protein tyrosine phosphatase, non-receptor type 12	5
<a href="#">55876</a>	GSDMB	gasdermin B	5
<a href="#">2804</a>	GOLGB1	golgin B1	5
<a href="#">57658</a>	CALCOCO1	calcium binding and coiled-coil domain 1	5
<a href="#">23558</a>	WBP2	WW domain binding protein 2	5
<a href="#">147339</a>	C18orf25	chromosome 18 open reading frame 25	5
<a href="#">79652</a>	TMEM204	transmembrane protein 204	5
<a href="#">29108</a>	PYCARD	PYD and CARD domain containing	5
<a href="#">23345</a>	SYNE1	spectrin repeat containing nuclear envelope protein 1	5
<a href="#">79026</a>	AHNAK	AHNAK nucleoprotein	5
<a href="#">57153</a>	SLC44A2	solute carrier family 44 member 2	5
<a href="#">10505</a>	SEMA4F	ssemaphorin 4F	5
<a href="#">6653</a>	SORL1	sortilin related receptor 1	5
<a href="#">333929</a>	SNAI3	snail family transcriptional repressor 3	5
<a href="#">1316</a>	KLF6	Kruppel like factor 6	5
<a href="#">166</a>	AES	amino-terminal enhancer of split	5
<a href="#">1043</a>	CD52	CD52 molecule	5
<a href="#">55728</a>	N4BP2	NEDD4 binding protein 2	5
<a href="#">10791</a>	VAMP5	vesicle associated membrane protein 5	5
<a href="#">5257</a>	PHKB	phosphorylase kinase regulatory subunit beta	5
<a href="#">23646</a>	PLD3	phospholipase D family member 3	5
<a href="#">492311</a>	IGIP	IgA inducing protein	5
<a href="#">9885</a>	OSBPL2	oxysterol binding protein like 2	5
<a href="#">10938</a>	EHD1	EH domain containing 1	5
<a href="#">1774</a>	DNASE1L1	deoxyribonuclease 1 like 1	5
<a href="#">2647</a>	BLOC1S1	biogenesis of lysosomal organelles complex 1 subunit 1	5
<a href="#">10870</a>	HCST	hematopoietic cell signal transducer	5
<a href="#">203523</a>	ZNF449	zinc finger protein 449	5
<a href="#">9924</a>	PAN2	PAN2 poly(A) specific ribonuclease subunit	5
<a href="#">133619</a>	PRRC1	proline rich coiled-coil 1	5
<a href="#">51276</a>	ZNF571	zinc finger protein 571	5
<a href="#">144699</a>	FBXL14	F-box and leucine rich repeat protein 14	5
<a href="#">389072</a>	PLEKHM3	pleckstrin homology domain containing M3	5
<a href="#">23518</a>	R3HDM1	R3H domain containing 1	5
<a href="#">23526</a>	ARHGAP45	Rho GTPase activating protein 45	5
<a href="#">7011</a>	TEP1	telomerase associated protein 1	5
<a href="#">54540</a>	FAM193B	family with sequence similarity 193 member B	5

<a href="#">284996</a>	RNF149	ring finger protein 149	5
<a href="#">11104</a>	KATNA1	katanin catalytic subunit A1	5
<a href="#">28971</a>	AAMDC	adipogenesis associated Mth938 domain containing	5
<a href="#">26053</a>	AUTS2	autism susceptibility candidate 2	5
<a href="#">399687</a>	MYO18A	myosin XVIIIa	5
<a href="#">57659</a>	ZBTB4	zinc finger and BTB domain containing 4	5
<a href="#">400986</a>	ANKRD36C	ankyrin repeat domain 36C	5
<a href="#">79741</a>	CCDC7	coiled-coil domain containing 7	5
<a href="#">1629</a>	DBT	dihydroipoamide branched chain transacylase E2	5
<a href="#">93624</a>	TADA2B	transcriptional adaptor 2B	5
<a href="#">162427</a>	FAM134C	family with sequence similarity 134 member C	5
<a href="#">107984583</a>			5
<a href="#">64788</a>	LMF1	lipase maturation factor 1	5
<a href="#">7994</a>	KAT6A	lysine acetyltransferase 6A	5
<a href="#">394</a>	ARHGAP5	Rho GTPase activating protein 5	5
<a href="#">389</a>	RHOC	ras homolog family member C	5
<a href="#">200186</a>	CRTC2	CREB regulated transcription coactivator 2	5
<a href="#">10066</a>	SCAMP2	secretory carrier membrane protein 2	5
<a href="#">9889</a>	ZBED4	zinc finger BED-type containing 4	5
<a href="#">403313</a>	PLPP6	phospholipid phosphatase 6	5
<a href="#">196528</a>	ARID2	AT-rich interaction domain 2	5
<a href="#">51780</a>	KDM3B	lysine demethylase 3B	5
<a href="#">5780</a>	PTPN9	protein tyrosine phosphatase, non-receptor type 9	5
<a href="#">84498</a>	FAM120B	family with sequence similarity 120B	5
<a href="#">23506</a>	GLTSCR1L	GLTSCR1 like	5
<a href="#">26207</a>	PITPNC1	phosphatidylinositol transfer protein, cytoplasmic 1	5
<a href="#">158358</a>	KIAA2026	KIAA2026	5
<a href="#">387748</a>	OR56B1	olfactory receptor family 56 subfamily B member 1	5
<a href="#">11201</a>	POLI	DNA polymerase iota	5
<a href="#">10211</a>	FLOT1	flotillin 1	5
<a href="#">200765</a>	TIGD1	tigger transposable element derived 1	5
<a href="#">118</a>	ADD1	adducin 1	5
<a href="#">284371</a>	ZNF841	zinc finger protein 841	5
<a href="#">5142</a>	PDE4B	phosphodiesterase 4B	5
<a href="#">55619</a>	DOCK10	dedicator of cytokinesis 10	5
<a href="#">23527</a>	ACAP2	ArfGAP with coiled-coil, ankyrin repeat and PH domains 2	5
<a href="#">23424</a>	TDRD7	tudor domain containing 7	5
<a href="#">373</a>	TRIM23	tripartite motif containing 23	5
<a href="#">338440</a>	ANO9	anoctamin 9	5
<a href="#">10000</a>	AKT3	AKT serine/threonine kinase 3	5
<a href="#">8569</a>	MKNK1	MAP kinase interacting serine/threonine kinase 1	5
<a href="#">84159</a>	ARID5B	AT-rich interaction domain 5B	5
<a href="#">26046</a>	LTN1	listerin E3 ubiquitin protein ligase 1	5
<a href="#">23041</a>	MON2	MON2 homolog, regulator of endosome-to-Golgi trafficking	5
<a href="#">60412</a>	EXOC4	exocyst complex component 4	5
<a href="#">4287</a>	ATXN3	ataxin 3	5
<a href="#">4343</a>	MOV10	Mov10 RISC complex RNA helicase	5
<a href="#">79800</a>	CARF	calcium responsive transcription factor	5
<a href="#">2776</a>	GNAQ	G protein subunit alpha q	5
<a href="#">55167</a>	MSL2	male-specific lethal 2 homolog (Drosophila)	5
<a href="#">83744</a>	ZNF484	zinc finger protein 484	5
<a href="#">64145</a>	RBSN	rabenosyn, RAB effector	5
<a href="#">55500</a>	ETNK1	ethanolamine kinase 1	5
<a href="#">317</a>	APAF1	apoptotic peptidase activating factor 1	5
<a href="#">51380</a>	CSAD	cysteine sulfinic acid decarboxylase	5
<a href="#">55902</a>	ACSS2	acyl-CoA synthetase short-chain family member 2	5
<a href="#">8567</a>	MADD	MAP kinase activating death domain	5
<a href="#">7776</a>	ZNF236	zinc finger protein 236	5

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**CURRICULUM VITAE**

