Annals of R.S.C.B., Vol. XIX, Issue 2, 2015, pp. 33 - 40
Received 13 March 2015; accepted 06 April 2015.
doi: 10.ANN/RSCB-2015-0005:RSCB

The expression of translin is regulated by inflammatory stimuli in monocytes and macrophages

E. V. FUIOR [(1)], I. M. FENYO [(1)] and A. V. GAFENCU [(1)*]
[1] *Institute of Cellular Biology and Pathology "Nicolae Simionescu" of the Romanian Academy*
**Corresponding author:*
Anca V. Gafencu, PhD
Institute of Cellular Biology and Pathology "Nicolae Simionescu" of the Romanian Academy
8, B.P. Hasdeu Street, 050568, Bucharest, Romania
Phone: +(40)021.319.4518; e-mail: anca.gafencu@icbp.ro

Keywords. Translin, monocyte, macrophage, inflammation, aspirin, dexamethasone.

Summary

Translin and translin-associated factor X are two highly conserved proteins with nucleic acid binding activities, which are considered to act as a sensor for cell survival and proliferation in various normal and stress-related conditions. Despite the progresses made in the characterization of their function, their physiological role is still elusive. In this work we show how translin expression is regulated in vitro in monocytes upon applying various differentiation stimuli, of significance to inflammatory processes. In addition, in animal studies, translin was found to be upregulated by aspirin and dexamethasone in mouse peritoneal macrophages. The data presented herein may indicate translin as a potential sensor or target for inflammation.

Introduction

Translin (Tsn) was discovered in 1995 as a single-stranded DNA-binding protein recognizing the sequences at chromosomal translocations breakpoints responsible for certain types of lymphomas (Aoki et al., 1995). Its murine homologue was independently identified as a RNA-binding protein in tissues with intense mRNA transport, such as brain and testis (Han *et al.*, 1995). Translin knock-out mice were viable, with no evident phenotypical changes, except being smaller than the wild-type individuals. Noteworthy, they exhibited a significant delay in the formation of spleen hematopoietic colonies after sublethal ionizing radiation (Fukuda *et al.*, 2008). It was found that translin functions in partnership with its highly homologous protein, translin-associated factor X, known as TRAX/Tsnax (Aoki *et al.*,1997). Their amino acid sequences are highly conserved in eukaryotes (Gupta *et al.*, 2012) and their partnership is rather highly preserved phylogenetically, from humans to Drosophila (Claussen *et al*., 2006) and S. pombe (Laufman *et al.*, 2005). This tandem of proteins was described as being an important switch or sensor in cell proliferation and survival in normal and stressed cells via changing its cellular localization or the ratio between the two components (Chennathukuzhi *et al.*, 2003; Yang *et al*., 2004). TRAX is endowed with a nuclear localization signal, while translin has a functional nuclear export signal, both taking part in a complex translocation to and from the nucleus in certain conditions (Cho *et al*., 2004). Translin/TRAX were found to act as glucose response element binding proteins (GRBP) in the liver (Wu *et al*., 2003). Recently, nucleic acid binding sites were described also on TRAX (Gupta and Kumar, 2012). There are many reports regarding the involvement of the two proteins in RNA interference processes. The most exciting discovery relates to their heteromeric association under the naming of C3PO, which acts as an endoribonuclease that promotes

doi: 10.ANN/RSCB-2015-0005:RSCB

RNA interference via facilitation of RNA Interference Silencing Complex (RISC) activation (Liu *et al.*, 2009). Despite the numerous reports regarding the pleiotropic activities from RNA trafficking to DNA repair and recombination, puzzling aspects remain to be elucidated, to further define the physiological activity of this protein couple.

Atherosclerosis, the leading cause of death in the world, is a chronic disease of the arteries, leading to the formation of characteristic plaques. Both lipid metabolism dysregulation and a pro-inflammatory status contribute to the evolution of the disease. Monocytes and macrophages participate in all the events leading to the establishment of the plaque (accumulation of lipids, release of pro-inflammatory and cytotoxic factors, remodeling of extracellular matrix). Plaque monocytes and macrophages are rather heterogeneous, the various subsets displaying different functions in atherogenesis (Fenyo and Gafencu, 2013). Within the atheromatous site, macrophages differentiate, proliferate and undergo apoptosis. Monocyte differentiation to macrophages aggravates atherosclerosis by establishing an inflammatory milieu within the vascular wall. Oxidative stress greatly influences the behaviour of both monocytes (priming, adhesion, recruitment) and macrophages (differentiation, activation, polarization, death) (Tavakoli and Asmis, 2012), thus contributing to the lesional state.

In this work we have focused on the modulation of translin gene expression by certain differentiation or pro- or anti-inflammatory stimuli in monocytes and macrophages. We have found that these signals modulate translin expression, suggesting that this protein may be a promising sensor or target in inflammatory processes.

Materials and methods

Chemicals: Taq DNA polymerase was purchased from Promega (Madison, WI, USA); M-MLV Reverse Transcriptase was from Invitrogen (Life Technologies Inc., Gaithersburg, MD); DMEM, RPMI-1640, fetal calf serum and TRIzol Reagent were from Invitrogen; ECL Western blotting kit was from Pierce (Rockford, USA); tetradecanoyl phorbol acetate (TPA) was from Promega corp. (Madison, WI,USA); lipopolysaccharide (LPS) was from SIGMA. The primers were obtained from Metabion Inc. (Martinsried, Germany). An aliquot of anti-translin antibody was kindly provided by Dr. Manor from the Department of Biology, Technion-Israel Institute of Technology, Haifa, Israel. All other antibodies were from Santa Cruz Biotechnology, Inc. (CA, United States). U937, RAW264.7 were from ATCC, VA, USA. Streptavidine-Texas Red was from Amersham.

Cell culture: U937 human monocytes (5x105cells/mL) were grown in RPMI, supplemented with 5% heat-inactivated fetal calf serum, in the presence of 100 μg/ml penicillin and 100 μg/ml streptomycin, at 37oC in a 5% CO2 incubator. The cells were differentiated with 120 nM PMA for 72 hours. Treatment with H2O2 0.5 mM was for 30', after which medium was replaced with fresh medium. Cells were harvested one day after the treatment was finished either for total, cytosolic or nuclear cell lysate or RNA preparation. RAW 264.7 murine macrophages (3x105) were grown in DMEM, supplemented with 10% fetal calf serum, in the presence of 100 μg/ml penicillin and 100 μg/ml streptomycin, at 37oC in a 5% CO2 incubator and treated with various stimuli.

Cell lysates preparation: For whole lysates preparation, after washing in phosphate buffer saline (PBS), cells were harvested in 2X electrophoresis loading buffer, as described by Laemmli (Laemmli, 1970).

Nuclear/ cytosolic fraction preparation: Nuclear extracts were prepared according to Dignam (Dignam et al., 1983). The cell pellets obtained by centrifugation at 3000 g for 5' were resuspended in lysis buffer (7 mM phosphate buffer, 1% Triton X-100 containing a cocktail of protease inhibitors). The suspension was passed through the needle of an insulin syringe. The lysate was

doi: 10.ANN/RSCB-2015-0005:RSCB
Received 13 March 2015; accepted 06 April 2015.

centrifuged at 750 g, for 10 min at 4ºC. The pelleted nuclei were resuspended in Laemmli buffer. The supernatants, representing the cytosolic fractions were precipitated with trichloracetic acid to a final concentration of 13.5%. After centrifugation at 12000 g for 10 min, pelleted cytosolic proteins were briefly washed with trichloracetic acid 10% to remove detergent traces and then solubilized in Laemmli buffer.

Protein assay: Protein concentrations were calculated according to the method of Sheffield (Sheffield *et al*., 1987), using bovine serum albumin (BSA) as a standard.

SDS-PAGE was performed in 12% polyacrylamide gels. On each lane 45 µg of protein were loaded.

Western blot. Cell lysates were subjected to SDS-PAGE on a 12% polyacrylamide gel and transferred onto nitrocellulose in a semi-dry system (BIO-RAD). The blots were probed with anti-translin antibody or anti-actin antibody, followed by horseradish peroxidase (HRP)-conjugated secondary antibodies. The protein bands were detected using ECL chemiluminescence technique as described by the manufacturer.

RT-PCR: Total RNA was prepared using TRIzol reagent according to the manufacturer instructions. From 1µg total RNA, cDNA was synthesized using oligo(dT)12-18 and M-MLV Reverse Transcriptase. PCR reactions were performed with the specific primers whose sequence is given in Table 1. The PCR Program was as follows: denaturation at 95ºC for 3'; 28 cycles of (denaturation: 95ºC, 30''; annealing: 55ºC, 30''; elongation: 72ºC, 30''); final elongation at 72ºC for 5'. The products were separated on 1.5% agarose gels, stained with Midori Green (Nippon Genetics) and analyzed by TotalLab Software.

Immunofluorescence: RAW 264.7 murine macrophages were seeded in 4-wells culture dishes on coverslips at 3x105 cells/mL. The following day, cells were incubated with the stimuli and fixed with methanol at the end of the treatment. After blocking with 1% BSA, samples were incubated sequentially with rabbit anti-translin antibody, anti-rabbit-biotin and Streptavidine-Texas Red, with appropriate washes in between. Lastly, the coverslips were mounted on microscope slides and viewed with a Nikon Microscope equipped with fluorescence accessories and camera.

Mouse models: Male C57BL/6 mice (Charles River Laboratories) were grown and fed rodent chow diet with ad libitum access to nutrients and water; they were exposed to a 12h cycle of light and dark. At the age of 10 weeks, animals were divided into the following experimental groups (n represents the number of individuals in each group):

1) Control mice which received 50µL/ water/mice/day, by gavage, for a 3 week period (n = 6).

2) Mice treated with aspirin (SIGMA): 100 µL/mice/day (dose 30 µg/mL in water) by gavage, for a period of 3 weeks (n=6);

3) Mice treated with dexamethasone (SIGMA): 100 µL/mice/day (dose 30mg/kg body weight) by gavage, for one week period (n=5).

At the end of the treatment period, at the age of 13 weeks, animals were injected i.p. with 1.5 ml thioglycolate to elicit peritoneal macrophages. After 72h from injection, animals were sacrificed through cervical dislocation, followed by harvesting through peritoneal lavage with 1‰ glucose-DMEM.

The experiments on animal models were performed in accordance with the provisions of EU Directive 86/609 in use at the time experiments were performed and of the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (ETS no. 123), and were approved by the ethical committee of our institution.

Table 1. Primers for gene expression analysis by RT-PCR.

Primer	Sequence	Expected size of the amplified fragment (bp)
Human Tsn-F	5'-TGGCAGCATTTGTTGTGTATTTGG	223
Human Tsn-R	5'-TTGATGAAGGTGGAGATGTGGAGG	
Human/mouse GAPDH-F	5'-ACCACAGTCCATGCCATCAC	452
Human/mouse GAPDH-R	5'-TCCACCACCCTGTTGCTGTA	
Mouse Tsn-F	5'-CATTGGCGGTTCGTGCTTCAG	404
Mouse Tsn-R	5'-GCCGCTGCTGTCTCCTTATTG	

Results and discussions

First, we evaluated translin expression in RAW 264.7 murine macrophages upon medium (hours) / long (days) exposure to certain stimuli, significant to the inflammatory status. Thus, we incubated RAW 264.7 cells with (i) 30 nM TPA (3h), (ii) 1.6μM TPA (3h), (iii) 1μg/mL LPS (3h), and (iv) 0.5 mM H_2O_2 in Hanks buffer in the presence of Fe^{2+}, when free $HO\cdot$ radicals are generated (30 min). After 30 min of H_2O_2 treatment, the medium was changed and cells were let to recover for 2h. Finally, cells were either subjected to immunofluorescence as described in the Materials and Methods section or total RNA was isolated and translin expression was evaluated by semi-quantitative RT-PCR, using GAPDH as reference. We have noticed a slight increase in the level of translin mRNA upon exposure to TPA (30 nM or 1.6 μM), LPS or H_2O_2 (1.34, 1.54, 1.2 respectively 1.34 fold increase, illustrated in Figure 1A). These data correlated with the increased fluorescence intensity of the treated cells probed with anti-translin antibody (Figure 1B). A cytosolic localization of the protein was evidenced in both control and stressed cells. No nuclear shuttling was apparent under the experimental conditions. When TPA treatment was prolonged up to 24 hours, RT-PCR experiments indicated a level close to the control (1.1 fold increase; data not shown).

Then, we have used a different experimental model, the human U937 monocytes which upon prolonged TPA treatment differentiate into macrophages, changing also their phenotype from non-adherent to adherent. The cells were incubated with 120 nM TPA for 72 hours, when all the cells became adherent. Upon this treatment, translin expression was significantly decreased, as revealed by Western blot (Figure 2A) and RT-PCR (Figure 2B). Also, the effect of reactive oxygen species was assessed, in the absence or in the presence of TPA (Figure 2A, 2B). When present, translin was still localized in the cytosol. Nuclear fractions were also probed for translin, but no protein was detected there (data not shown). Similar data were obtained in another monocytic cell line, THP-1 (not shown).

Annals of R.S.C.B., Vol. XIX, Issue 2, 2015, pp. 33 - 40
Received 13 March 2015; accepted 06 April 2015.
doi: 10.ANN/RSCB-2015-0005:RSCB

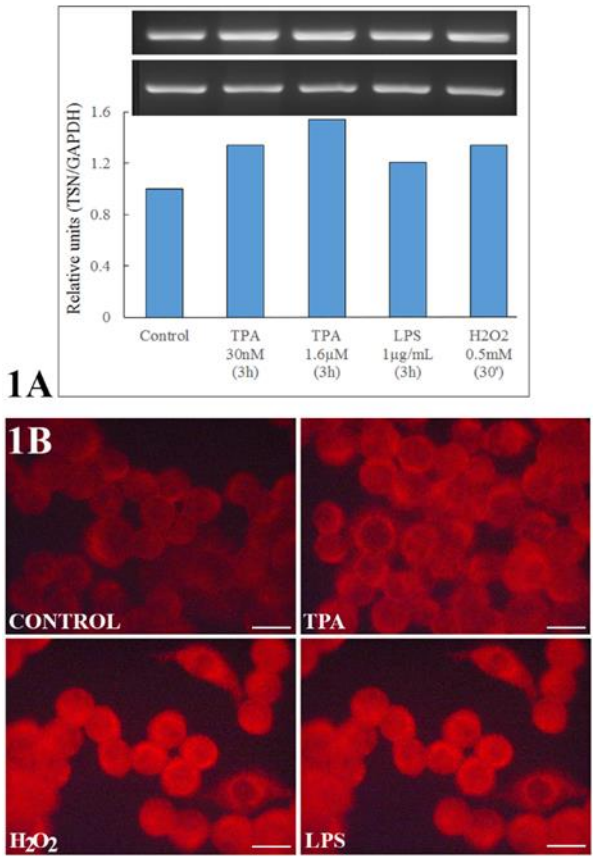

Figure 1. Translin expression in RAW 264.7 cells after medium term exposure to various stimuli. A. RAW 264.7 were incubated with TPA (30 nM or 1.6 µM) for 3h, LPS (1µg/mL) for 3h or H_2O_2 (0.5 mM) for 30 min. Total RNA was isolated and translin expression was semi-quantitated by RT-PCR; the upper and the lower bands represent translin, respectively GAPDH product. The graphed data represent the quantitation of the Midori Green-stained bands by TotalLab software; **B.** Immunofluorescence of RAW 264.7 cells incubated with TPA (30nM), LPS (1µg/mL) or H_2O_2 (0.5 mM) for the durations indicated in **A**. Cells were probed with anti-translin antibody, followed by anti-rabbit-biotin and Streptavidine-Texas Red and viewed with a fluorescence microscope. Bar is 10 µm.

Finally, we have also investigated the effect of certain anti-inflammatory agents on translin expression, in macrophages isolated from treated mice. To this aim, a non-steroidal (aspirin) and a steroid (dexamethasone) were administrated to C57BL/6 mice, as described in the Materials and Methods section. We have noticed that both compounds significantly increased translin expression in mouse peritoneal macrophages. Three-weeks treatment with aspirin, at a dose of 3µg/100µL/day or one-week treatment with dexamethasone (30mg/kg body weight), led to an increase of around 1.5-, respectively 2- fold, under the experimental conditions used. These values were found to be of statistical significance, based on t-test ($p<0.05$).

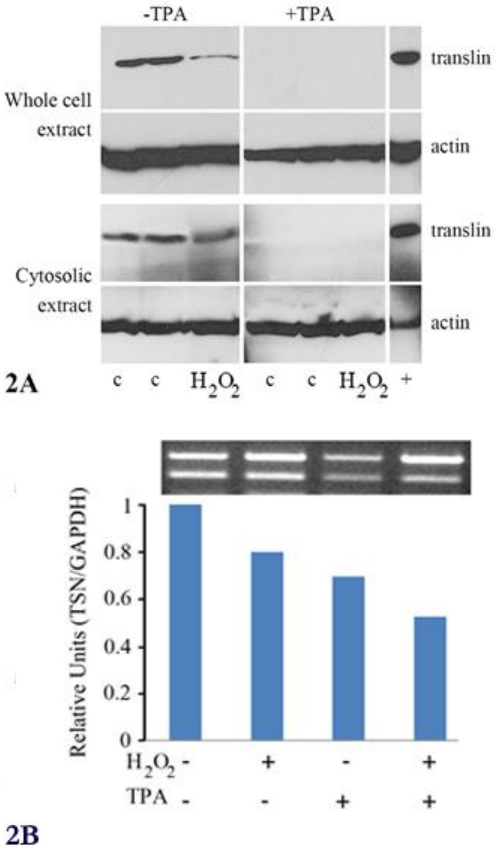

Figure 2. Translin expression in U937 human monocytes/macrophages. A. TPA and H2O2 decrease translin expression in U937 cells, but do not affect its cytosolic localization, as revealed by Western Blot. The last lane is loaded with a cell extract, used as positive control. B. Oxidative stress reduces translin expression in U937 human monocyte/macrophages, as assessed by RT-PCR. The upper and the lower bands represent GAPDH, respectively translin product. The graphed data represent the quantitation of the Midori Green-stained bands by TotalLab software.

Discussion

Translin is a single stranded-DNA and RNA binding protein. Since its discovery, many data accumulated regarding its function in DNA and RNA processing in partnership with TRAX. Its multitude of functions raises a question mark regarding its physiological role. Its high expression in myeloid and

doi: 10.ANN/RSCB-2015-0005:RSCB

lymphoid cells have opened a line of research in the field of hematopoietic differentiation. The differentiation of monocytes into macrophages involves mechanisms for inducing a response of the innate immune system to inflammatory challenges, such as pathogens or environmental stimuli. In this work we focused on the action of LPS, TPA or free radicals to investigate how they affect translin expression. We performed these studies in the context of the pro-inflammatory status, similar with that found in atheromatous sites.

Exogenous LPS induces a pro-inflammatory state which may contribute to the atherosclerosis progression. Recently, the synergy between dietary lipids, endogenous endotoxemia and low-grade inflammation, defined as "metabolic endotoxemia" was demonstrated to affect cardiovascular physiology (Laugerette et al., 2011). In our study, we have noticed a slight increase in translin expression upon 3h exposure of RAW 264.7 murine macrophages to LPS (Figure 1A, lane LPS). No modification of intracellular distribution of the protein was detectable by immunofluorescence (Figure 1B).

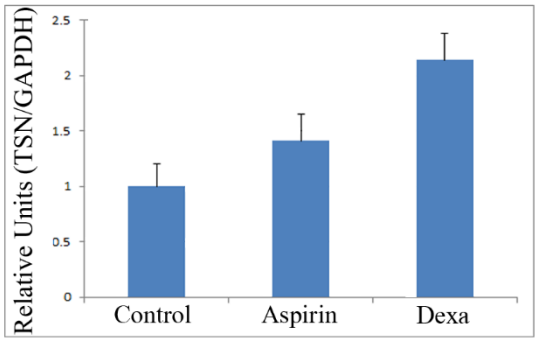

Figure 3. Anti-inflammatory agents upregulate translin expression in mouse peritoneal macrophages. Total RNA was isolated from peritoneal macrophages from mice treated with aspirin (3µg/ mouse /day for 3 weeks) or dexamethasone (30mg/kg body weight, for one week). Translin expression was measured by RT-PCR and the products separated on agarose gel were quantified using TotalLab software.

TPA can act as an activator of protein kinase C, and, based on this, it functions as a tumor promoter. It also induces the production of superoxide, but not other radicals in rat macrophages (Swindle *et al*., 2002). TPA is known to induce differentiation of human monocyte cell lines, like U937 or THP-1. In our experiments, short term exposure to TPA in RAW macrophages modestly increased translin level, in a dose-dependent manner (Figure 1A, TPA lanes), while TPA-induced differentiation of U937 monocytes drastically down-regulated translin expression, without affecting its cytosolic localization (Figure 2A).

Free radicals which aggravates plaque formation slightly increased translin expression in RAW cells, but decreased it in U937 cells, either when presented alone or in conjunction with other stimuli (TPA).

Excepting the drastic reduction of translin expression in TPA-differentiated U937 cells, most of the changes remained relatively modest. One may ask if these were of biological relevance, or whether they were at the limit of the experimental error. We believe that these studies need to be continued to find the doses or the period of exposure to induce a maximal perturbation.

More relevant changes we have recorded in mouse peritoneal macrophages upon anti-inflammatory treatments with non-steroidal or steroid compounds.

Aspirin is used in atherosclerosis therapy, as it reduces the risk for myocardial infarction; its effects on plaque stabilization are thought to mainly occur via two mechanisms: inhibition of matrix metalloproteinase (MMP)-9 and nuclear factor kB (NF-kB) and increased cholesterol efflux by enhanced expression of ATP-binding cassette transporter ABCA-1 and scavenger receptor SR-BI (Lu et al., 2010). In our study, we noticed that although in extremely low dose, aspirin administration to mice increased translin expression ~1.5 times in the peritoneal macrophages (Figure 4). Of course, since the aspirin treatment for cardiovascular pathologies in humans needs to be administered for long periods of time, it would be of interest to follow this experiment for an extended duration.

Dexamethasone, a synthetic ligand for the glucocorticoid receptor, is known for its differentiating effects on myeloid leukemia cells (Hicsonmez, 2006). It is also used in

doi: 10.ANN/RSCB-2015-0005:RSCB

various inflammatory conditions, including atherosclerosis. In our study, one-week treatment increased two-fold translin expression in mouse peritoneal macrophages.

The results presented herein show that different mechanisms may regulate translin expression in macrophages upon exposure to various inflammatory stimuli. As we have seen in Figure 2B, concomitant application of two stimuli (TPA and H2O2) had an additive effect upon decreasing translin expression. It would be now of interest to establish how certain signalling pathways affect the expression of this protein.

The data reported in this work show a modulation of translin expression in inflammatory circumstances. Similar results to our data obtained in TPA-differentiated U937 macrophages showing the significant reduction of translin were reported for another cell line, the erythroleukemic K562 (Fukuda *et al*., 2008).

These results are of importance to follow-up. An interesting hypothesis to verify would be that the involvement of translin/TRAX in monocyte differentiation may partly account for the effects exerted by certain anti-psychotic drugs. It was recently demonstrated that antipsychotic drugs induce immune regulation (Chen *et al*., 2013) It was found that, in rat cortex, translin was one of the few genes modulated by administration of imipramine and citalopram (Palotas *et al*., 2004), while TRAX expression was specifically increased by risperidone, but not by clozapine (Kedracka-Krok *et al*., 2014).

Conclusion

In this paper we presented some evidence for the modulation of the nucleic acid binding protein, translin, under exposure to pro- or anti-inflammatory stimuli. These studies open the avenue for investigating the potential of this protein as a sensor or a target in inflammatory conditions. We are confident that results presented in this work and future developments will lead to a better understanding of the involvement of translin in the cardiovascular pathology.

Acknowledgements

This work was supported by a grant of the Romanian National Authority for Scientific Research, National Research Council – Executive Agency for Higher Education, Research, Development and Innovation Funding (CNCS – UEFISCDI), PN-II-ID-PCE-2011-3-0591 (a grant awarded to A. Gafencu), and by the Romanian Academy, I.M. Fenyo acknowledges the support of the strategic grant POSDRU/159/1.5/S/133391 - financed by the European Social Found within the Sectorial Operational Program Human Resources Development 2007 – 2013.
We are deeply grateful to Dr. Manor of the Department of Biology, Technion-Israel Institute of Technology, Haifa, Israel for providing us an aliquot of anti-translin antibody. We acknowledge the help of Dr. Ovidiu Croitoru with graphic design.

References

Aoki K, Suzuki K, Sugano T, Tasaka T, Nakahara K, Kuge O, Omori A, Kasai M. A novel gene, Translin, encodes a recombination hotspot binding protein associated with chromosomal translocations. Nat Genet, 10, 2, 167-74, 1995

Aoki K, Ishida R, Kasai M. Isolation and characterization of a cDNA encoding a Translin-like protein, TRAX. FEBS Lett., 401, 2-3, 109-12, 1997

Chen ML, Wu S, Tsai TC, Wang LK, Tsai FM. Regulation of macrophage immune responses by antipsychotic drugs. Immunopharmacol Immunotoxicol., 35, 5, 573-80, 2013

Cho YS, Chennathukuzhi VM, Handel MA, Eppig J, Hecht NB The relative levels of translin-associated factor X (TRAX) and testis brain RNA-binding protein determine their nucleocytoplasmic distribution in male germ cells. J Biol Chem., 279, 30, 31514-23, 2004

Claussen M, Koch R, Jin ZY, Suter B. Functional characterization of Drosophila Translin and Trax. Genetics, 174, 3, 1337-47, 2006

Chennathukuzhi V, Stein JM, Abel T, Donlon S, Yang S, Miller JP, Allman DM, Simmons RA, Hecht NB. Mice deficient for testis-brain RNA-binding protein exhibit a coordinate loss of TRAX, reduced fertility, altered gene expression in the brain, and behavioral changes.Mol Cell Biol., 23, 18, 6419-34, 2003

Dignam JD, Lebovitz RM, Roeder RG. Accurate transcription initiation by RNA polymerase II in a

doi: 10.ANN/RSCB-2015-0005:RSCB

soluble extract from isolated mammalian nuclei. Nucleic Acids Res.11, 5:1475-89, 1983

Fenyo IM, Gafencu AV. The involvement of the monocytes/macrophages in chronic inflammation associated with atherosclerosis. Immunobiology, 218, 11, 1376-84, 2013

Fukuda Y, Ishida R, Aoki K, Nakahara K, Takashi T, Mochida K, Suzuki O, Matsuda J, Kasai M. Contribution of Translinto hematopoietic regeneration after sublethal ionizing irradiation. Biol Pharm Bull., 31, 2 : 207-11, 2008

Gupta GD, Kale A, Kumar V. Molecular evolution of Translin superfamily proteins within the genomes of eubacteria, archaea and eukaryotes. J Mol Evol., 75, 5-6, 155-67, 2012

Gupta GD, Kumar V. Identification of nucleic acid binding sites on translin-associated factor X (TRAX) protein. PLoS One, 7, 3,e33035, 2012

Han JR, Gu W, Hecht NB Testis-brain RNA-binding protein, a testicular translational regulatory RNA-binding protein, is present in the brain and binds to the 3' untranslated regions of transported brain mRNAs. Biol Reprod., 53, 3, 707-17, 1995 Hiçsönmez G. The effect of steroid on myeloid leukemic cells: the potential of short-course high-dose methylprednisolone treatment in inducing differentiation, apoptosis and in stimulating myelopoiesis. Leuk Res. 30, 1, 60-8, 2006

Kedracka-Krok S, Swiderska B, Jankowska U, Skupien-Rabian B, Solich J, Buczak K, Dziedzicka-Wasylewska M. Clozapine influences cytoskeleton structure and calcium homeostasis in rat cerebral cortex and has a different proteomic profile than risperidone J Neurochem. doi: 10.1111/jnc.13007, 2014

Laemmli UK.Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature, 5;227(5259):680-5, 1970

Laufman O, Ben Yosef R, Adir N, Manor H. Cloning and characterization of the Schizosaccharomyces pombe homologs of the human protein Translinand the Translin-associated protein TRAX. Nucleic Acids Res. 2005 Jul 25;33(13):4128-39

Laugerette F, Vors C, Peretti N, Michalski MC.Complex links between dietary lipids, endogenous endotoxins and metabolic inflammation Biochimie 93, 1, 39-45, 2011

Liu Y, Ye X, Jiang F, Liang C, Chen D, Peng J, Kinch LN, Grishin NV, Liu Q. C3PO, an endoribonuclease that promotes RNAi by facilitating RISC activation. Science. 325, 5941, 750-3, 2009

Lu L, Liu H, Peng J, Gan L, Shen L, Zhang Q, Li L, Zhang L, Su C, Jiang Y. Regulations of the key mediators in inflammation and atherosclerosis by aspirin in human macrophages. Lipids Health Dis. 6, 9:16, 2010

Palotás M, Palotás A, Puskás LG, Kitajka K, Pákáski M, Janka Z, Molnár J, Penke B, Kálmán J. Gene expression profile analysis of the rat cortex following treatment with imipramine and citalopram. Int J Neuropsychopharmacol. 7, 4, 401-13, 2004

Sheffield JB, Graff D, Li HP. A solid-phase method for the quantitation of protein in the presence of sodium dodecyl sulfate and other interfering substances. Anal Biochem. 166, 1, 49-54, 1987

Swindle EJ, Hunt JA, Coleman JW. A comparison of reactive oxygen species generation by rat peritoneal macrophages and mast cells using the highly sensitive real-time chemiluminescent probe pholasin: inhibition of antigen-induced mast cell degranulation by macrophage-derived hydrogen peroxide. J Immunol. 169,10:5866-73, 2002

Tavakoli S, Asmis R. Reactive oxygen species and thiol redox signaling in the macrophage biology of atherosclerosis. Antioxid Redox Signal. 17, 12, 1785-9, 2012

Yang S, Cho YS, Chennathukuzhi VM, Underkoffler LA, Loomes K, Hecht NB. Translin-associated factor X is post-transcriptionally regulated by its partner protein TB-RBP, and both are essential for normal cell proliferation. J Biol Chem. 279, 13:12605-14, 2004

Wu RF, Osatomi K, Terada LS, Uyeda K. Identification of Translin/Trax complex as a glucose response element binding protein in liver. Biochim Biophys Acta 1624,1-3, 29-35, 2003.