



Chapter 2

A Cholesterol and Actinide Dependent Shadow Biosphere of Archaea and Viroids in Retroviral and Prion Disease

Introduction

Dietary fibre deficiency leads to increased endosymbiotic as well as colonic archaeal growth and recurrent RNA viral epidemics/prion disease. The endosymbiotic archaea regulates human functions and species type and depends upon the colonic archaea whose density is determined by the fibre intake. The colonic archaeal population density depends upon dietary fibre intake. Populations with low fibre intake have lesser density of colonic archaeal microflora and endosymbiotic archaea. Endosymbiotic archaea contributes to neanderthalisation of the species. Populations consuming a high saturated fat and protein diet with low fibre intake tend to get increased endosymbiotic archaeal growth and are neanderthalised. Populations with high fibre intake up to 80 g/day tend to have reduced archaeal density in the colon and reduced archaeal endosymbiosis contributing to homo sapienisation of the population. Thus fibre intake regulates the endosymbiotic archaeal density and type of human species.

Endomyocardial fibrosis (EMF) along with the root wilt disease of coconut is endemic to Kerala with its radioactive actinide beach sands. Actinides like rutile producing intracellular magnesium deficiency due to rutile-magnesium exchange sites in the cell membrane have been implicated in the etiology of EMF.¹ Endogenous digoxin, a steroidal glycoside which functions as a membrane sodium potassium ATPase inhibitor has also been related to its etiology due to the intracellular magnesium deficiency it produces.² Organisms like phytoplasmas and viroids have also been demonstrated to play a role in the etiology of these diseases.^{3, 4} Endogenous digoxin has been related to the pathogenesis of acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease.² The possibility of endogenous digoxin synthesis by actinide based primitive organism like archaea with a mevalonate pathway and cholesterol catabolism was considered.⁵⁻⁷ Davies has put forward the concept of a shadow

biosphere of organisms with alternate biochemistry present in earth itself.⁸ An actinide dependent shadow biosphere of archaea and viroids in the above mentioned disease states is described.⁶

Materials and Methods

Informed consent of the subjects and the approval of the ethics committee were obtained for the study. The following groups were included in the study: - acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease. There were 10 patients in each group and each patient had an age and sex matched healthy control selected randomly from the general population. The blood samples were drawn in the fasting state before treatment was initiated. Plasma from fasting heparinised blood was used and the experimental protocol was as follows: (I) Plasma+phosphate buffered saline, (II) same as I+cholesterol substrate, (III) same as II+rutile 0.1 mg/ml and, (IV) same as II+ciprofloxacin and doxycycline each in a concentration of 1 mg/ml. Cholesterol substrate was prepared as described by Richmond.⁹ Aliquots were withdrawn at zero time immediately after mixing and after incubation at 37 °C for 1 hour. The following estimations were carried out: - Cytochrome F420, free RNA, free DNA, muramic acid, polycyclic aromatic hydrocarbon, hydrogen peroxide, serotonin, pyruvate, ammonia, glutamate, cytochrome C, hexokinase, ATP synthase, HMG CoA reductase, digoxin and bile acids.¹⁰⁻¹³ Cytochrome F420 was estimated fluorimetrically (excitation wavelength 420 nm and emission wavelength 520 nm). Polycyclic aromatic hydrocarbon was estimated by measuring hydrogen peroxide liberated by using glucose reagent. The statistical analysis was done by ANOVA.

Results

The parameters checked as indicated above were: - cytochrome F420, free RNA, free DNA, muramic acid, polycyclic aromatic hydrocarbon, hydrogen peroxide, serotonin, pyruvate, ammonia, glutamate, cytochrome C, hexokinase, ATP synthase, HMG CoA reductase, digoxin and bile acids. Plasma of control subjects showed increased levels of the above mentioned parameters with after incubation for 1 hour and addition of cholesterol substrate resulted in still further significant increase in these parameters. The plasma of patients showed similar results but the extent of increase was more. The addition of antibiotics to the control plasma caused a decrease in all the parameters while addition of rutile increased their levels. The addition of antibiotics to the patient's plasma caused a decrease in all the parameters while addition of rutile increased their levels but the extent of change was more in patient's sera as compared to controls. The results are expressed in tables 1-7 as percentage change in the parameters after 1 hour incubation as compared to the values at zero time.

Table 1. *Effect of rutile and antibiotics on muramic acid and serotonin.*

Group	Muramic acid % change (Increase with Rutile)		Muramic acid % change (Decrease with Doxy+Cipro)		5 HT % (Increase without Doxy)		5 HT % (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.41	0.15	18.63	0.12	4.34	0.15	18.24	0.37
AIDS	23.43	1.57	66.30	3.57	22.98	1.50	65.13	4.87
CJD	23.70	1.75	68.06	3.52	23.81	1.49	64.89	6.01
F value	403.394		680.284		348.867		364.999	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 2. *Effect of rutile and antibiotics on free DNA and RNA.*

Group	DNA % change (Increase with Rutile)		DNA % change (Decrease with Doxy)		RNA % change (Increase with Rutile)		RNA % change (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.37	0.15	18.39	0.38	4.37	0.13	18.38	0.48
AIDS	22.56	2.46	62.70	4.53	23.32	1.74	65.67	4.16
CJD	23.30	1.42	65.07	4.95	23.11	1.52	66.68	3.97
F value	337.577		356.621		427.828		654.453	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 3. *Effect of rutile and antibiotics on HMG CoA reductase and PAH.*

Group	HMG CoA R % change (Increase with Rutile)		HMG CoA R % change (Decrease with Doxy)		PAH % change (Increase with Rutile)		PAH % change (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.30	0.20	18.35	0.35	4.45	0.14	18.25	0.72
AIDS	22.86	2.58	66.53	5.59	23.23	1.97	65.89	5.05
CJD	22.38	2.38	60.65	5.27	23.46	1.91	61.56	4.61
F value	319.332		199.553		391.318		257.996	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 4. *Effect of rutile and antibiotics on digoxin and bile acids.*

Group	Digoxin (ng/ml) (Increase with Rutile)		Digoxin (ng/ml) (Decrease with Doxy+Cipro)		Bile acids % change (Increase with Rutile)		Bile acids % change (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	0.11	0.00	0.054	0.003	4.29	0.18	18.15	0.58
AIDS	0.56	0.05	0.220	0.052	22.29	1.47	64.35	5.58
CJD	0.53	0.06	0.212	0.045	23.30	1.88	62.49	7.26
F value	135.116		71.706		290.441		203.651	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 5. *Effect of rutile and antibiotics on pyruvate and hexokinase.*

Group	Pyruvate % change (Increase with Rutile)		Pyruvate % change (Decrease with Doxy)		Hexokinase % change (Increase with Rutile)		Hexokinase % change (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.34	0.21	18.43	0.82	4.21	0.16	18.56	0.76
AIDS	21.21	2.36	58.73	8.10	21.11	2.25	64.20	5.38
CJD	21.07	1.79	63.90	7.13	22.47	2.17	65.97	4.62
F value	321.255		115.242		292.065		317.966	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 6. *Effect of rutile and antibiotics on hydrogen peroxide and delta amino levulinic acid.*

Group	H ₂ O ₂ % (Increase with Rutile)		H ₂ O ₂ % (Decrease with Doxy)		ALA % (Increase with Rutile)		ALA % (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.43	0.19	18.13	0.63	4.40	0.10	18.48	0.39
AIDS	23.32	1.71	63.15	7.62	23.45	1.79	66.32	3.63
CJD	22.86	1.91	63.66	6.88	23.17	1.88	68.53	2.65
F value	380.721		171.228		372.716		556.411	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Table 7. *Effect of rutile and antibiotics on ATP synthase and cytochrome F420.*

Group	ATP synthase % (Increase with Rutile)		ATP synthase % (Decrease with Doxy)		CYT F420 % (Increase with Rutile)		CYT F420 % (Decrease with Doxy)	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Normal	4.40	0.11	18.78	0.11	4.48	0.15	18.24	0.66
AIDS	23.15	1.62	66.48	4.17	22.29	1.66	59.02	7.50
CJD	23.00	1.64	66.67	4.21	22.06	1.61	57.81	6.04
F value	449.503		673.081		306.749		130.054	
P value	< 0.001		< 0.001		< 0.001		< 0.001	

Discussion

Dietary Fibre Deficiency, Endosymbiotic Archaea and Cholesterol Catabolism - Relation to Prion Disease and Retroviral Infection

Dietary fibre deficiency leads to increased endosymbiotic as well as colonic archaeal growth. There was increase in cytochrome F420 indicating archaeal growth in acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease. The archaea can synthesise and use cholesterol as a carbon and energy source.^{14, 15} The archaeal origin of the enzyme activities was indicated by antibiotic induced suppression. The study indicates the presence of actinide based archaea with an alternate actinide based enzymes or metalloenzymes in the system as indicated by rutile induced increase in enzyme activities.¹⁶ There was also an increase in archaeal HMG CoA reductase activity indicating increased cholesterol synthesis by the archaeal mevalonate pathway. The archaeal beta hydroxyl steroid dehydrogenase activity indicating digoxin synthesis and archaeal cholesterol hydroxylase activity indicating bile acid synthesis were increased.⁷ The archaeal cholesterol oxidase activity was increased resulting in generation of pyruvate and hydrogen peroxide.¹⁵ The pyruvate gets converted to glutamate and ammonia by the GABA shunt pathway. The archaeal aromatization of cholesterol generating PAH, serotonin and dopamine was also detected.¹⁷ The archaeal glycolytic hexokinase activity and archaeal extracellular ATP synthase activity were increased. The archaea can undergo magnetite and calcium carbonate mineralization and can exist as calcified nanoforms.¹⁸ There was an increase in free RNA indicating self replicating RNA viroids and free DNA indicating generation of viroid complementary DNA strands by archaeal reverse transcriptase activity. The actinides modulate RNA folding and catalyse its ribozymal action. Digoxin can cut and paste the viroidal strands by modulating RNA splicing generating RNA

viroidal diversity. The viroids are evolutionarily escaped archaeal group I introns which have retrotransposition and self splicing qualities.¹⁹ Archaeal pyruvate can produce histone deacetylase inhibition resulting in endogenous retroviral (HERV) reverse transcriptase and integrase expression. This can integrate the RNA viroidal complementary DNA into the noncoding region of eukaryotic noncoding DNA using HERV integrase as has been described for borna and ebola viruses.²⁰ The noncoding DNA is lengthened by integrating RNA viroidal complementary DNA with the integration going on as a continuing event. The archaea genome can also get integrated into human genome using integrase as has been described for trypanosomes.²¹ The integrated viroids and archaea can undergo vertical transmission and can exist as genomic parasites.^{20, 21} This increases the length and alters the grammar of the noncoding region producing memes or memory of acquired characters.²² The viroidal complementary DNA can function as jumping genes producing a dynamic genome modulating DNA transcription. The RNA viroids can regulate mRNA function by RNA interference.¹⁹ The phenomena of RNA interference can modulate T cell and B cell function, insulin signalling lipid metabolism, cell growth and differentiation, apoptosis, neuronal transmission and euchromatin/heterochromatin expression. The RNA viroids can recombine with HERV sequences and get encapsulated in microvesicles contributing to the retroviral state. Prion proteins can bind nucleic acids. The prion protein conformation is modulated by RNA viroid binding resulting in prion disease. RNA viroid induced mRNA interference can contribute to cell death in AIDS dementia, malignant transformation and autoimmunity in the acquired immunodeficiency syndrome.

Dietary Fibre Deficiency, Endosymbiotic Archaea and Genomic Change - Relation to Prion Disease and Retroviral Infection

The presence of muramic acid, HMG CoA reductase and cholesterol oxidase activity inhibited by antibiotics indicates the presence of bacteria with mevalonate pathway. The bacterial with mevalonate pathway include streptococcus, staphylococcus, actinomycetes, listeria, coxiella and borrelia²³ The bacteria and archaea with mevalonate pathway and cholesterol catabolism had a evolutionarily advantage and constitutes the isoprenoidal clade organism with the archaea evolving into mevalonate pathway gram positive and gram negative organism through horizontal gene transfer of viroidal and virus genes.^{24, 25} The isoprenoidal clade prokaryotes develop into other groups of prokaryotes via viroidal/virus as well as eukaryotic horizontal gene transfer producing bacterial speciation.²⁶ The RNA viroids and its complementary DNA developed into cholesterol enveloped RNA and DNA viruses like herpes, retrovirus, influenza virus, borna virus, cytomegalo virus and ebstein barr virus by recombining with eukaryotic and human genes resulting in viral speciation. Bacterial and viral species are ill defined and fuzzy with all of them forming one common genetic pool with frequent horizontal gene transfer and recombination. Thus the multi and unicellular eukaryote with its genes serves the purpose of prokaryotic and viral speciation. The multicellular eukaryote developed so that their endosymbiotic archaeal colonies could survive and forage better. The multicellular eukaryotes are like bacterial biofilms. The archaea and bacteria with a mevalonate pathway uses the extracellular RNA viroids and DNA viroids for quorum sensing and in the generation of symbiotic biofilm like structures which develop into multicellular eukaryotes.^{27, 28} The endosymbiotic archaea and bacteria with mevalonate pathway still uses the RNA viroids and DNA viroids for the regulation of multicellular eukaryote. Pollution is induced by the primitive nanoarchaea and mevalonate pathway

bacteria synthesized PAH and methane leading on to redox stress. Redox stress leads to sodium potassium ATPase inhibition, inward movement of plasma membrane cholesterol, defective SREBP sensing, increased cholesterol synthesis and nanoarchaeal/mevalonate pathway bacterial growth.²⁹ Redox stress leads on to viroidal and archaeal multiplication. Redox stress can also lead to HERV reverse transcriptase and integrase expression. The noncoding DNA is formed of integrating RNA viroidal complementary DNA and archaea with the integration going on as a continuing event. The archaeal pox like dsDNA virus forms evolutionarily the nucleus. The integrated viroidal, archaeal and mevalonate pathway bacterial sequences can undergo vertical transmission and can exist as genomic parasites. The genomic integrated archaea, mevalonate pathway bacteria and viroids form a genomic reserve of bacteria and viruses which can recombine with human and eukaryotic genes producing bacterial and viral speciation. Bacteria and viruses have been related to the pathogenesis of acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease. Mycoplasmas have been described as co-factors in HIV infection.³⁰ Mycoplasma infection of the cell can result in expression of HERV sequences. Changes in the length of noncoding region especially human endogenous retroviruses and the expression of HERV sequences can contribute to the pathogenesis of AIDS syndrome.³¹ The change in the length and grammar of the noncoding region produces eukaryotic speciation and individuality.³² The integration of nanoarchaea, mevalonate pathway prokaryotes and viroids in to the eukaryotic and human genome produces a chimera which can multiply producing biofilm like multicellular structures having a mixed archaeal, viroidal, prokaryotic and eukaryotic characters which is a regression from the multicellular eukaryotic tissue. This results in a new neuronal, metabolic, immune and tissue phenotype or microchimera leading to human diseases like acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease. The

microchimera produces polyploidy which has been related to malignant transformation, autoimmune disease and neuronal degeneration like AIDS dementia described in acquired immunodeficiency syndrome.

Dietary Fibre Deficiency, Endosymbiotic Archaea and Neuro-Endocrine-Immune Dysregulation - Relation to Prion Disease and Retroviral Infection

Archaea and RNA viroid can bind the TLR receptor induce NF κ B producing immune activation and cytokine TNF alpha secretion. The archaeal DXP and mevalonate pathway metabolites can bind $\gamma\delta$ TCR and digoxin induced calcium signalling can activate NF κ B producing chronic immune activation.^{2, 33} The archaea and viroid can induce chronic immune activation and generation of superantigens. Chronic immune activation can lead onto an increase in CD₄ receptor and chemokine receptor density producing a predilection to develop acquired immunodeficiency syndrome. The generation of superantigens leads to autoimmunity and increased incidence of autoimmune vasculitis and arthritis common in AIDS. The archaea and viroids can regulate the nervous system including the NMDA synaptic transmission.² NMDA can be activated by digoxin induced calcium oscillations, PAH and viroid induced RNA interference.² The cholesterol ring oxidase generated pyruvate can be converted by the GABA shunt pathway to glutamate. The archaeal cholesterol aromatase can generate serotonin.¹⁷ Glutamatergic and serotonergic transmission can lead to immune activation important in the pathogenesis of AIDS. NMDA excitotoxicity and neurotransmitter induced immune activation can lead onto AIDS dementia. The increased generation of serotonin and dopamine from bacterial cholesterol catabolism can lead to mood disorders and schizophreniform psychosis common in AIDS. The higher degree of integration of the archaea into the genome produces increased digoxin synthesis producing

right hemispheric dominance and lesser degree producing left hemispheric dominance.² Right hemispheric dominance can lead to acquired immunodeficiency syndrome as has been reported previously from this laboratory. Archaea, viroids and digoxin can induce the host AKT PI3K, AMPK, HIF alpha and NFkB producing the Warburg metabolic phenotype.³⁴ The increased glycolytic hexokinase activity, decrease in blood ATP, leakage of cytochrome C, increase in serum pyruvate and decrease in acetyl CoA indicates the generation of the Warburg phenotype. There is induction of glycolysis, inhibition of PDH activity and mitochondrial dysfunction resulting in inefficient energetics. The increased glycolysis results in the upregulation of mitochondrial PT pore hexokinase resulting in cell proliferation and malignant transformation. The archaeal cholesterol catabolism also generates PAH which can modulate gap junction intercellular communication resulting in cell proliferation and malignant transformation. Archaeal PAH can thus induce neoplastic change. Archaeal cholesterol catabolism can deplete the cells of cholesterol leading onto polyploidy and malignant transformation. There is increased incidence of malignancies is like non-Hodgkin's lymphomas and Kaposi's sarcoma in AIDS. The lymphocytes depend on glycolysis for their energy needs. The increased glycolysis induced by the Warburg phenotype leads to immune activation. Lactic acid generated by increased glycolysis leads to immune stimulation. Immune stimulation is an association of AIDS syndrome. Cholesterol oxidase activity, increased glycolysis related NADPH oxidase activity and mitochondrial dysfunction generates free radicals important in the pathogenesis of AIDS. Free radicals are used by the HIV virus as messengers and increase retroviral replication and the viral load in the system. The accumulated pyruvate enters the GABA shunt pathway and is converted to citrate which is acted upon by citrate lyase and converted to acetyl CoA, used for cholesterol synthesis.³⁴ The pyruvate can be converted to glutamate and ammonia which is oxidised by

archaea for energy needs. The increased cholesterol substrate also leads to increased archaeal growth and digoxin synthesis leading to metabolic channelling to the mevalonate pathway. Hyperdigoxinemia is important in the pathogenesis of AIDS. Digoxin can increase lymphocytic intracellular calcium which leads on to induction of NF κ B and immune activation. Digoxin can also induce EGF and other growth factors resulting in oncogenesis. Digoxin can produce increased intracellular calcium related PT pore dysfunction and cell death.² The archaeal cholesterol catabolism generated PAH can also produce NMDA excitotoxicity and cell death. The archaeal and mevalonate pathway bacteria cholesterol catabolism can deprive cholesterol from neuronal cell membrane and organelle membranes like mitochondrial, ER and lysosomal membranes producing cellular and organelle dysfunction and death. The Warburg phenotype is also important in neuronal degeneration producing AIDS dementia. The increased glycolysis results in increased generation of the enzyme glyceraldehyde 3-phosphate dehydrogenase (GAPD). GAPD can undergo polyadenylation via free radical activated PARP enzyme. The polyadenylated GAPD can undergo nuclear translocation producing nuclear cell death. All of these contribute to the genesis of neuronal degeneration and AIDS dementia. The AIDS dementia, malignant transformation, immune activation and autoimmune disease which are all part of the HIV syndrome can be related to the archaea and viroids. The cholesterol catabolism by archaea and mevalonate pathway bacteria results in cholesterol depletion from the host which has been described in AIDS. Cholesterol metabolic defects have also been described in Creutzfeldt Jakob's disease. Thus the actinide, viroid and mevalonate pathway bacteria induced metabolic, genetic, immune and neuronal transmission changes can lead onto acquired immunodeficiency syndrome and Creutzfeldt Jakob's disease.

References

- [1] Valiathan M. S., Somers, K., Kartha, C. C. (1993). *Endomyocardial Fibrosis*. Delhi: Oxford University Press.
- [2] Kurup R., Kurup, P. A. (2009). *Hypothalamic Digoxin, Cerebral Dominance and Brain Function in Health and Diseases*. New York: Nova Science Publishers.
- [3] Hanold D., Randies, J. W. (1991). Coconut cadang-cadang disease and its viroid agent, *Plant Disease*, 75, 330-335.
- [4] Edwin B. T., Mohankumaran, C. (2007). Kerala wilt disease phytoplasma: Phylogenetic analysis and identification of a vector, *Proutista moesta*, *Physiological and Molecular Plant Pathology*, 71(1-3), 41-47.
- [5] Eckburg P. B., Lepp, P. W., Relman, D. A. (2003). Archaea and their potential role in human disease, *Infect Immun*, 71, 591-596.
- [6] Adam Z. (2007). Actinides and Life's Origins, *Astrobiology*, 7, 6-10.
- [7] Schoner W. (2002). Endogenous cardiac glycosides, a new class of steroid hormones, *Eur J Biochem*, 269, 2440-2448.
- [8] Davies P. C. W., Benner, S. A., Cleland, C. E., Lineweaver, C. H., McKay, C. P., Wolfe-Simon, F. (2009). Signatures of a Shadow Biosphere, *Astrobiology*, 10, 241-249.
- [9] Richmond W. (1973). Preparation and properties of a cholesterol oxidase from nocardia species and its application to the enzymatic assay of total cholesterol in serum, *Clin Chem*, 19, 1350-1356.
- [10] Snell E. D., Snell, C. T. (1961). *Colorimetric Methods of Analysis*. Vol 3A. New York: Van Nostrand.
- [11] Glick D. (1971). *Methods of Biochemical Analysis*. Vol 5. New York: Interscience Publishers.
- [12] Colowick, Kaplan, N. O. (1955). *Methods in Enzymology*. Vol 2. New York: Academic Press.

- [13] Maarten A. H., Marie-Jose, M., Cornelia, G., van Helden-Meewsen, Fritz, E., Marten, P. H. (1995). Detection of muramic acid in human spleen, *Infection and Immunity*, 63(5), 1652 - 1657.
- [14] Smit A., Mushegian, A. (2000). Biosynthesis of isoprenoids via mevalonate in Archaea: the lost pathway, *Genome Res*, 10(10), 1468-84.
- [15] Van der Geize R., Yam, K., Heuser, T., Wilbrink, M. H., Hara, H., Anderton, M. C. (2007). A gene cluster encoding cholesterol catabolism in a soil actinomycete provides insight into Mycobacterium tuberculosis survival in macrophages, *Proc Natl Acad Sci USA*, 104(6), 1947-52.
- [16] Francis A. J. (1998). Biotransformation of uranium and other actinides in radioactive wastes, *Journal of Alloys and Compounds*, 271(273), 78-84.
- [17] Probian C., Wülfing, A., Harder, J. (2003). Anaerobic mineralization of quaternary carbon atoms: Isolation of denitrifying bacteria on pivalic acid (2,2-Dimethylpropionic acid), *Applied and Environmental Microbiology*, 69(3), 1866-1870.
- [18] Vainshtein M., Suzina, N., Kudryashova, E., Ariskina, E. (2002). New Magnet-Sensitive Structures in Bacterial and Archaeal Cells, *Biol Cell*, 94(1), 29-35.
- [19] Tsagris E. M., de Alba, A. E., Gozmanova, M., Kalantidis, K. (2008). Viroids, *Cell Microbiol*, 10, 2168.
- [20] Horie M., Honda, T., Suzuki, Y., Kobayashi, Y., Daito, T., Oshida, T. (2010). Endogenous non-retroviral RNA virus elements in mammalian genomes, *Nature*, 463, 84-87.
- [21] Hecht M., Nitz, N., Araujo, P., Sousa, A., Rosa, A., Gomes, D. (2010). Genes from Chagas parasite can transfer to humans and be passed on to children. Inheritance of DNA Transferred from American Trypanosomes to Human Hosts, *PLoS ONE*, 5, 2-10.
- [22] Flam F. (1994). Hints of a language in junk DNA, *Science*, 266, 1320.
- [23] Horbach S., Sahm, H., Welle, R. (1993). Isoprenoid biosynthesis in bacteria: two different pathways? *FEMS Microbiol Lett*, 111, 135-140.

- [24] Gupta R. S. (1998). Protein phylogenetics and signature sequences: a reappraisal of evolutionary relationship among archaebacteria, eubacteria, and eukaryotes, *Microbiol Mol Biol Rev*, 62, 1435-1491.
- [25] Margulis L. (1996). Archaeal-eubacterial mergers in the origin of Eukarya: phylogenetic classification of life. *Proc Natl Acad Sci USA*, 93, 1071-1076.
- [26] Hanage W., Fraser, C., Spratt, B. (2005). Fuzzy species among recombinogenic bacteria, *BMC Biology*, 3, 6-10.
- [27] Webb J. S., Givskov, M., Kjelleberg, S. (2003). Bacterial biofilms: prokaryotic adventures in multicellularity, *Curr Opin Microbiol*, 6(6), 578-85.
- [28] Whitchurch C. B., Tolker-Nielsen, T., Ragas, P. C., Mattick, J. S. (2002). Extracellular DNA Required for Bacterial Biofilm Formation. *Science*, 295(5559), 1487.
- [29] Chen Y., Cai, T., Wang, H., Li, Z., Loreaux, E., Lingrel, J. B. (2009). Regulation of intracellular cholesterol distribution by Na/K-ATPase, *J Biol Chem*, 284(22), 14881-90.
- [30] Montagnier L., Blanchard, A. (1993). Mycoplasmas as cofactors in infection due to the human immunodeficiency virus. *Clin Infect Dis*, 17(1), S309-15.
- [31] Villarreal L. P. (2006). How viruses shape the tree of life, *Future Virology*, 1(5), 587-595.
- [32] Poole A. M. (2006). Did group II intron proliferation in an endosymbiont-bearing archaeon create eukaryotes? *Biol Direct*, 1, 36-40.
- [33] Eberl M., Hintz, M., Reichenberg, A., Kollas, A., Wiesner, J., Jomaa, H. (2010). Microbial isoprenoid biosynthesis and human $\gamma\delta$ T cell activation, *FEBS Letters*, 544(1), 4-10.
- [34] Wallace D. C. (2005). Mitochondria and Cancer: Warburg Addressed, *Cold Spring Harbor Symposia on Quantitative Biology*, 70, 363-374.