

Time in a Timeless Environment

My Life in a Bunker

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studies circadian rhythms in honeybees, mice and humans. She has had the rare privilege of being both an experimental subject as well as an author of a scientific study as you will read in this article.

The fact that every organism possesses an endogenous biological clock can be established when they are made to live in conditions of timelessness. How do human beings perform under such conditions? Human isolation facilities provide such timeless environments where human beings can live comfortably while performing various bodily activities as dictated by their endogenous clock. In this article, I narrate my personal experience in the isolation facility at Madurai Kamaraj University. My stay (on three occasions) has led to the important finding that the menstrual cycle in a human female is not coupled to the sleep-wake cycle. I also describe how such experiments can be useful in the context of shift-working, jet-lag and space studies.

A Bunker?

When you had to prepare for an exam or catch an early flight or train, you probably had the experience of getting up just before the alarm went off. This is possible because of the biological clock that we all possess. Just as we set our watches with standard times from the radio or TV, our body also sets its clock to a 24 hour schedule with the help of cues that are provided by the environment. For instance, the cycle bell of the milkman is sufficient for us to realise that the day has dawned, without even opening our eyes. Other factors such as light, temperature and noise can also provide us with information about time. Almost all physiological parameters in human beings are rhythmic, i.e. they repeat themselves at definite time intervals. For example, the time we go to sleep, the time we wake up, our body temperature, levels of sodium and potassium excretion, water excretion — virtually anything you can think of is rhythmic. All these rhythmic functions take place

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because of the information of time received from the environment we live in.

What would happen if we are made to live in an environment which does not have time cues of any sort? What would happen if we lost track of time? How important is it to have the knowledge of time? All these interesting questions can be answered if we indeed have an environment that completely lacks time cues. In fact such environments have been created in five places in the world! Since these 'time less environments' have been created for conducting experiments on human beings they are called 'facilities'. All five such facilities in the world are rather similar, so let me describe the one in India. Believe me, I can describe it well — I have lived in this timeless facility for a total period of about 100 days (in three bouts)!

Timelessness in the Bunker!

The only isolation facility that we have in India is located in the Department of Animal Behaviour and Physiology, Madurai Kamaraj University (*Figure 1*). The others are located in USA, UK, Switzerland and Japan. The living quarter in the facility is a

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Figure 1 Photograph exhibiting a view of the human isolation chamber.

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25' x 25' room. It is window-less to ensure that daylight does not enter. Artificial lights (fluorescent tubelights with intensity of about 1300 to 1800 lx) are provided for the use of the subject who stays inside. Switching 'on' and 'off' of these lights is left to the discretion of the subjects. The walls of the room are double-layered with sand in between so that no outside noise can be heard. An ambient temperature of about 25° C is maintained throughout the experimental period. For ventilation purposes cool air is passed into the room through a duct with sound muffles. A kitchenette and a bathroom with toilet are attached to the living room. All facilities such as refrigerator, video cassette player, tape recorder, an ergometer for exercising purposes, tables, chairs and materials for cooking are provided in the chamber. The isolation facility is devoid of potential *zeitgebers*¹ (time-givers), viz. clocks, radios, TV, current periodicals etc. The requirements of the subject who stays inside are placed in the antechamber adjoining the isolation facility. Communication with the outside world is in the form of written notes. The facility is manned round the clock from outside. In case of power failures, a generator is switched on within minutes. During the period of stay, all the requirements of the subject are taken care of almost instantaneously! In short, the subject receives 'royal treatment' throughout the duration of the stay!

¹The cues that give the information of time to the organisms so that they are synchronised with the oscillator.

What Happens in the Bunker?

A number of interesting experiments have been performed in the isolation facilities. Juergen Aschoff and R Wever from Germany performed the pioneering experiments on human circadian rhythms². The experiments conducted in the isolation facility (which is now defunct) in Germany demonstrated for the first time that human beings continue to show rhythms even in the absence of time cues and this rhythmicity is endogenous and dependent on internal clocks. This was done by measuring the sleep-wake cycle (the times of going to sleep and waking up every day) under periods of isolation. Since, we wake up almost at the same time each day under normal conditions, the time difference between the wake-up time of two successive days would be almost

²Self-sustained biological rhythms which repeat once in about 24 hours.



24 hours i.e. it is entrained (synchronised) to the 24 hour light-dark cycle of nature. Under periods of isolation, this synchronisation no longer prevails and the subjects are found to drift from the normal 24h cycle, and start free-running³. So their sleep-wake cycle would have a period longer than 24 hours under isolation. Aschoff and Wever also proved that for humans, social cues can bring about entrainment⁴ to 24 hours thus proving that social cues are more important than light-dark (LD) cycles.

³The state of the rhythm in constant conditions in the absence of any time cues where the endogenous period is exhibited.

⁴Synchronization of a self-sustaining rhythm with the period of the imposed *zeitgeber*.

Following these findings, a number of similar experiments have been performed all over the world. Our isolation chamber in India also boasts of a number of interesting findings. Experiments have been carried out here since 1987 when the first subject G Marimuthu, a rhythm researcher himself, entered the isolation chamber in Madurai. During my first visit to the Department of Animal Behaviour, where they specialise in chronobiology (the study of biological rhythms), I happened to have a glimpse of it and instantly, wished to be the next subject. Fortunately for me, the head of the Department, M K Chandrashekar, who has built this 'one-of-a-kind-chamber', almost immediately agreed to make me the next experimental subject. Since I was involved in these experiments, let me give you a detailed account of how these experiments are generally performed, along with my personal experiences. There was a short spell of pre-isolation period, when I was asked to note down the times of going to sleep and waking up. I also had my core body temperature measured every 6 minutes by using a device called solicorder which records the temperature in a computer chip.

There is a reason behind measuring the body temperature. Though human beings are supposed to be homeotherms, there is a 2° C variation in body temperature every day. Temperature rises to a maximum around midday and dips to a minimum when we are in deep sleep (*Figure 2*). Since the time at which we go to sleep is almost the same every day, the time at which this temperature minimum occurs would also be at approximately 24-hour intervals. Therefore, the temperature cycle (the time interval between

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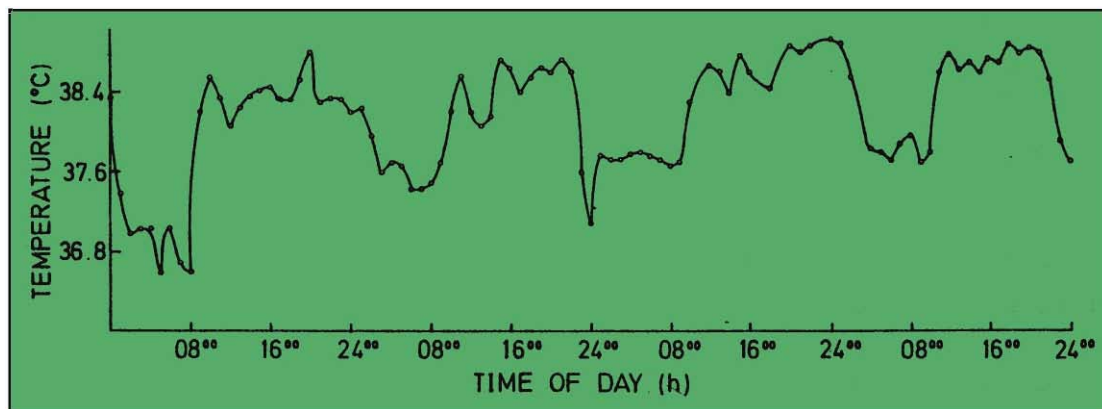


Figure 2 Graph showing the variations in temperature during the course of the day. Each 24 hours in the graph represents one day. Data collected during pre-isolation period for four days has been plotted here. Minimum temperature occurred when I was in deep sleep and maximum temperature almost during mid-day.

the occurrence of temperature minima of two successive days) would also be about 24 hours. Since we wanted to know whether this temperature rhythm would exhibit any change under isolation, my core body temperature was also measured during pre-isolation, isolation and post-isolation periods. One day prior to my isolation, I was asked to spend the night in the chamber just to get acquainted with the environment and to see if there were any problems which had to be rectified. I entered the isolation chamber on 4th May, 1989 for the first time. I happened to be the first female subject to go in and you can imagine the publicity that I received! All my friends jestingly remarked that I chose the month of May to stay in the chamber to evade the heat of the Madurai sun!

My Life in the Bunker

Thus, my stay in the isolation chamber commenced around 5 p.m. with an august gathering seeing me off! Personally, for me it was a dream coming true! All along I had wanted to be alone somewhere! Never did I dream that, that 'somewhere' was going to be a gorgeous place like the isolation chamber and that I would live like a princess there. We had done an enormous amount of 'shopping' for my stay the previous evening and I essentially spent the first few hours unpacking and organising. A kind of peace that I had never experienced before in my life enveloped me when I went to bed on the first day of my isolation. The next morning I opened my eyes to look for the time in the clock and with a jolt

remembered that this was the isolation chamber and that I would not know the time for quite some time! Gradually, I got used to my life of loneliness and timelessness in the chamber. It was indeed a unique experience in which there was no time restriction to do anything. There was no need to wake up, go to sleep, eat or do anything at a particular time and there was nobody to give me exhortations of any sort. It was a life that I lived for myself and I felt great about it. Incidentally, I feel this was one situation where we can realize how much we comply with the needs of society and make compromises!

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In spite of the lack of restrictions, I was somewhat organised although I performed all the activities, whenever they suited me! There is a panel of 20 buttons on one of the walls, each one corresponding to a particular function. For example, No. 1 corresponds to 'wake up', No. 2 for 'out of bed' and so on. I was supposed to activate these buttons as and when I performed these functions which got recorded outside in a device called an 'event recorder'. Thus, at a given time, the people outside knew what I was doing. For example, my sleep-wake cycle was monitored from outside by finding out when I was going to sleep and when I was waking up. I also pressed the button on channel No. 8, whenever I thought 2 hours had elapsed. This is called 'time estimation' to see how accurately a subject can measure the passage of time in a time-less environment. My ambulatory movements were measured by an activity-monitor which I wore on my left hand. With all these paraphernalia, I was quite a sight, but it did feel great to look different. Only, there was no one to look at me!

Apart from the 'pressing of buttons' I did not have anything much to do for the sake of the experiment. The whole day was mine to spend as I wished. I spent my time reading, watching movies, listening to music and generally relaxing and enjoying myself. Of course, at times, I also read some chronobiology. The rest of the time, I spent in trying out new recipes. Generally, the subjects are asked to cook their own food because of the problems encountered in providing food from outside. For example, the first subject who

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entered isolation demanded *idlis* when it was 3 AM in the outside world and it took enormous efforts for the outsiders to arrange for *idlis* at that time. As you realise, they could not even tell him that *idlis* were not easily available at that time of the day. Dealing with the psyche of the subject inside is a tricky affair, because even small failures might lead to giving some inadvertent time cues. Hence, from then on, the subjects were asked to prepare their own food. Usually all the subjects who entered (7 people had lived in it before me) lost weight. I had visions of a 'very slim self' coming out of the chamber after the experiment, and in fact it did happen! I had lost 5 kgs on the whole! The reason for this was known to me only after the experiment was over and I came out of the chamber. In fact, it was quite a surprise (and a shock!) for me when I was told that the experiment was over and that I had to come out. This is because, originally, it was agreed that I would live in the chamber for at least a month. But, at the time they called me out, I had counted only 22 days! I was quite cross with the people outside for abruptly stopping the experiment after 22 days. A few minutes after I came out of the chamber, I was asked to guess the date. I said, much to the amusement of people around, that it was 26th May when in reality, it was 8th of June! I had lost 13 precious days of my life. But I feel, it was all worth it! In short, I had spent 35 calendar days as 22 subjective days (subjective day is the time that I presumed to be one day as opposed to the calendar day). My rhythm started drifting every day after my entry and my period of wakefulness kept increasing day by day and so did my duration of sleep. Thus, I had been awake for a maximum of 34 hours and had slept for a maximum of 19 hours! As a consequence, the duration of my one day inside was on an average 45.9 hours. This is called 'circa-bidian' i.e. about 48 hours per day. So my sleep-wake cycle had a rhythm of about 45.9 hours (*Figures 3, 4*). Interestingly, my temperature rhythm still maintained about 24-hour rhythmicity, i.e. temperature minima continued to occur once in about 24 hours despite the variation in the sleep-wake cycle. My body temperature started coming to a minimum twice a day (once when I was awake and should have gone to sleep and once more when I was actually asleep). As a result, I had two temperature minima



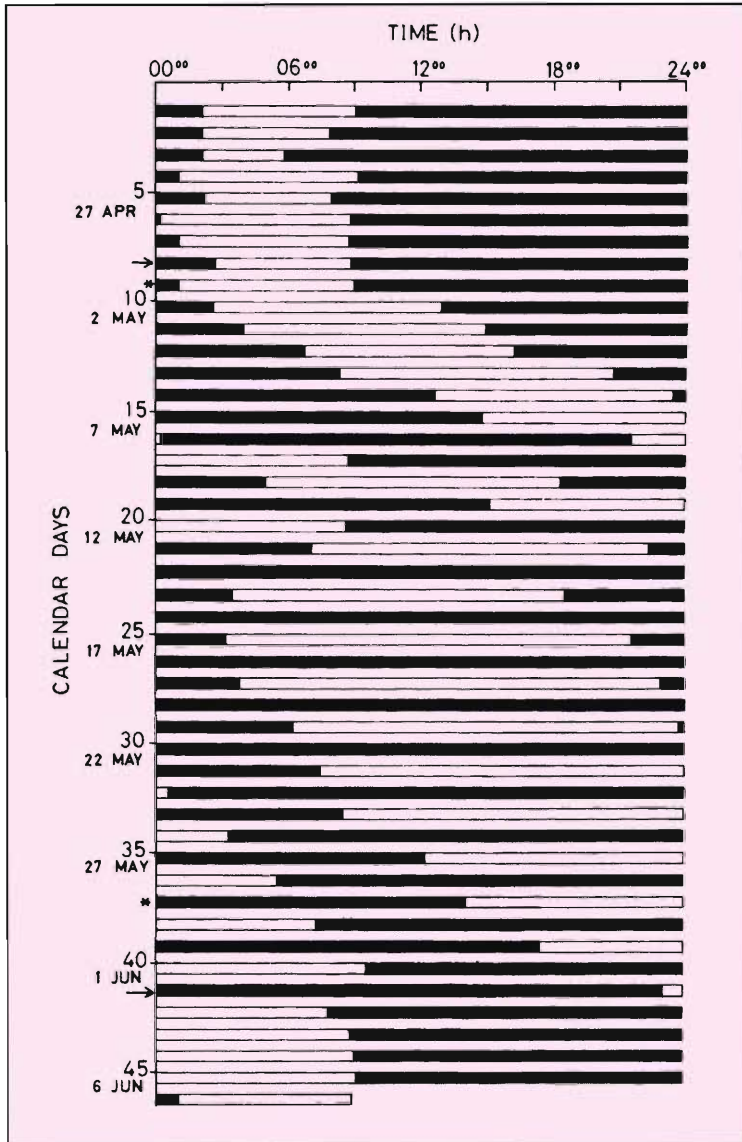


Figure 3 The times of sleep and wakefulness of my second stay in isolation, plotted on a 24 hour scale. Each line in the graph represents one calendar day. Darkened bars indicate the period of wakefulness and hollow bars indicate period of sleep. The arrow on the 8th day (30.04.1991) represents the day I entered the isolation chamber and the one on 02.05.1991 represents the day I came out of it. The asterisk on 01.05.1991 indicates the day of onset of the first menstrual cycle and the one on 29.05.1991 indicates the day of onset of the second menstrual cycle. Note that the period of wakefulness and sleep increased every day and gradually stabilised towards the end of the stay. The maximum time I kept awake was around 34 hours and the maximum time that I slept was around 19 hours at a stretch. You can notice that some days I never slept at all! (for example 18th May, 20th May and 22nd May).

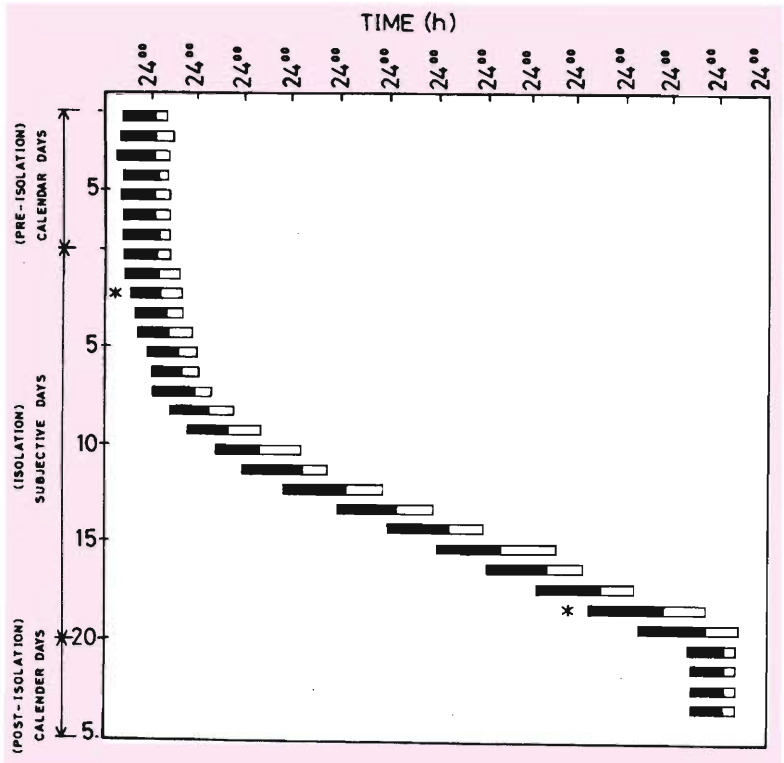
per subjective day and the temperature had a period⁵ of about 25.1 hours. In other words, my sleep-wake temperature and rhythm were in a state of 'desynchronisation'.

Generally, under normal societal conditions, both the sleep-wake cycle and the temperature cycle have the same period of about 24 hours. In such a condition, they are said to be 'synchronised'.

⁵ Time interval between recurrences of a defined phase of the rhythm.



Figure 4 The times of going to sleep and wakefulness of my second isolation plotted according to my subjective days. This is a multiple plot, plotted in such a way that it is easier to observe the course of the rhythm when you look at it. The first 8 days were pre-isolation data and each line here represents a calendar day. The period of isolation has been represented in subjective days (the days that I counted as opposed to the actual calendar days). Subjective day 1 starts on the 9th day in the graph and subjective day 20 is the last day of my isolation. Darkened bars indicate periods of wakefulness and hollow bars represent durations of sleep. Note that under pre and post isolation conditions the rhythm was in an entrained state, having an almost 24 hour rhythm and under isolation it free-runs. The period increased gradually and towards the end of the isolation period, it came to about 48 hours (circa bidlan). Asterisks on the two occasions indicate onset of menstrual cycles. Note how the rhythm stabilises in the post-isolation period.



However, when a person is under isolation, the sleep-wake cycle may free-run with periods deviating from 24 hours. In such cases, the temperature cycle need not deviate, but can and most often will maintain its approximately 24 hour rhythmicity. Such a condition is called 'internal desynchronisation'. This is a proof that our bodily rhythms may be controlled by more than one clock.

Now, we had an interesting question to ask: would the menstrual cycle follow the sleep-wake cycle or the temperature cycle? Since I had experienced only 22 days, if it had to follow my sleep-wake cycle, it should occur after I experience 28 subjective days. On the other hand, if it follows the temperature cycle, it should have occurred after 28 calendar days. In my case, menstrual cycle occurred after 28 *calendar* days. It did not depend on the sleep-wake rhythm. Interestingly, re-adjustment to the societal condition occurred almost instantly. My sleep-wake rhythm started to have about a 24 hour period almost from the second day of my exit



from the chamber. You can imagine how strong the effect of social cues is to the human circadian rhythms! Since it is very difficult to get a female subject who has a circa-bidian rhythm, whose rhythm desynchronises and who has a regular 28 day menstrual cycle, it is difficult to repeat such experiments. Nevertheless, we wanted to test the validity of our results. The only way was to repeat the same experiment on the same subject i.e me! To exclude the influences of circannual rhythms (rhythms which repeat themselves in about a year) in the physiological parameters and seasonal variations if any, it was also decided to perform the experiment at the same time of the year, but two years later.

So I Did It Again!

So, for the second time in my life (in May 1991) I had another sojourn in the isolation chamber. Everything else was the same except that two years had elapsed and now I had more responsible activities to do, like reading reprints, analysing my data on the circadian rhythms of mice and so on. So, this time I spent my time in a more constructive fashion. The only precaution that I took was to take care that the knowledge of my previous results did not influence my thinking. This time my stay was truly terminated prematurely (after 32 calendar days of isolation) and there was a good reason behind that. When I was in the middle of my stay, Rajiv Gandhi was assassinated and the situation was chaotic outside. I think I must have been one of the very few people in the whole world who did not hear about it in time! Apart from the difficulties faced by the people outside in providing my requirements, there was another problem associated with this ignorance. Every day I was supplied with my subjective day's newspaper. Since I was again having a circa-bidian rhythm and as a result, losing days, the monitoring committee could still keep providing me with newspapers without the news of assassination for some time. On 2nd of June, 1991, it was 22nd of May for me inside and they were not sure if I would endure the shock alone and hence asked me to come out on that day. So, my exit from the chamber the second time, lacked all the exhilarations of the first time

The menstrual cycle occurred after 28 *calendar* days. It did not depend on the sleep-wake rhythm.



because of this news. It was a great shock to me indeed to hear the news. After coming out of the chamber, I had to continue wearing the solicorder for my post-isolation data. This time, I faced a peculiar problem. The solicorder unit has two wires attached to a small box and the box with the wires is quite conspicuous when one wears it. Just a few days after the assassination, imagine what would happen if a girl walked around with a box having two protruding wires!

The results of the second experiment proved the validity of the first one in the sense that we had obtained almost the same data as in the first experiment. This time my sleep-wake cycle had a period of about 46.1 hours and my temperature cycle, 24.4 hours. Desynchronisation occurred on subjective day 9 and menstrual cycle occurred exactly 28 calendar days later, thus confirming the results of the previous experiment. Re-entrainment to the societal conditions again occurred as earlier.

The results of the second experiment proved the validity of the first one in the sense that we had obtained almost the same data as in the first experiment.

In addition, results of these two and other experiments that were performed earlier proved that there is a direct correlation between the 2 hour time estimation and the sleep-wakefulness rhythm. The subjects who had about a 24 hour rhythm estimated 2 hours almost correctly, whereas, subjects like me, who had a 48 hour rhythm estimated almost 6 hours as 2 hours. Hence, it is possible for the people outside to guess approximately how long the person is going to stay up that day, by observing the first 2 hour estimation of the day!

Where Can It Lead To?

One might pause to wonder why at all these experiments are being performed. Such studies can provide useful suggestions to people whose rhythm is disrupted such as shift workers, astronauts and people who travel across time-zones. Their sleep-wake rhythms measured under isolation and the period thus estimated, might provide information as to how efficient they would be while under disrupted day-night conditions. Their work load can be so sched-



uled as to match this efficiency period. For people who face problems of 'jet-lag' after inter-continental travel, such studies can furnish useful information about readjustment.

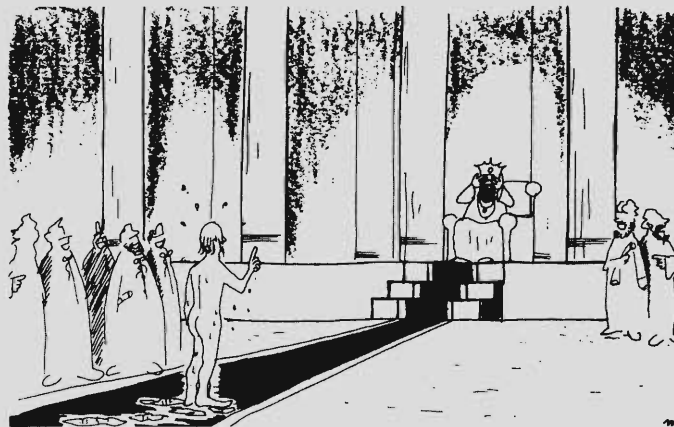
Suggested Reading

- J Aschoff.** Human Circadian Rhythms: a Multi-oscillator System. *Federation Proceedings*. 35, 2326-32. 1976.
- J Aschoff.** Circadian Rhythms in Man. in: *Biological Time Keeping*. (Ed) J Brady. Society for Experimental Biology Seminar Series 14. Cambridge University Press. 1982.
- M K Chandrashekar, L Geetha, G Marimuthu, R Subbaraj, P Kumarasamy, M S Ramkumar.** The Menstrual Cycle in a Human Female under Social and Temporal Isolation is Not Coupled to the Circadian Rhythm in Sleep-Wakefulness. *Curr. Sci.* 60, (12) 703-705. 1991.
- M K Chandrashekar, G Marimuthu, R Subbaraj, P Kumarasamy, M S Ramkumar, K Sripathi.** Direct Correlation Between the Circadian Sleep-Wakefulness Rhythm and Time Estimation in Humans under Social and Temporal Isolation. *J Biosci.* 16, 3, 97-101. 1991.
- M K Chandrashekar.** Circadian Rhythms, Menstrual Cycles and Time Sense in Humans Under Social Isolation. in: *Evolution of Circadian Clock*. (Eds) T Hiroshige, K Honma. Hokkaido Univ Press Sapporo. 263-274. 1994.
- R T W L Conroy, J N Mills.** Human Circadian Rhythms. K & A Churchill, London. 1970.
- M Siffre.** Six Months Alone in a Cave. *National Geographic*, March 1975.
- R Wever.** The Circadian System of Man. Springer Verlag Berlin, Heidelberg, New York. 1979.

Results of these two and other experiments that were performed earlier proved that there is a direct correlation between the 2 hour time estimation and the sleep-wakefulness rhythm.

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THAT'S FINE, ARCHIMEDES ! . . . BUT THIS IS NOT THE WAY TO GET MY ATTENTION!

MOHAN DEVADAS

