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Cover Page, Introduction, Contents, Call for Papers, All papers in one file

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Decline of the Asian Elephants (*Elephas maximus*) from Hardwar Forest Range of the Rajaji National Park, India: The First Documented Case of Free-Ranging Wildlife Species

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Abstract: Study on Asian elephant's population composition and impact of developmental activities on elephant's seasonal movement was made during 2000-2001 and 2006-2007 in Hardwar forest range of the Rajaji National Park, north-west India and is discussed. During 2000-2001, a total of 91 recognised elephants were sighted whereas only 31 elephants were observed during 2006-2007. Long-term field observations indicated that population composition of elephants was almost same during both the study periods but their number has decreased to three folds since last seven years. Developmental activities are increasingly recognized as the cause of mass mortality events, and population declines of wildlife species. In a number of cases, it has been hypothesized that huge amount of habitat deterioration have caused extinctions of wildlife species. However, few of the other natural reasons are also responsible for the decline in the population of wildlife. In this article, we review the potential involvement of developmental activities in the recent decline of the Asian elephant *Elephas maximus*. Our review of available evidence suggests that tremendous amount of developmental activities, shrinkage of water and fodder resources, running traffic and railway track, have caused a rapid catastrophic decline of this species from the Hardwar forest range of the Rajaji National Park area. We propose that this is the first case of decline of a free-ranging wildlife species where industrialization and urbanization acted as both the proximate and ultimate cause of species decline. This highlights probable anthropogenic activity as a cause of biodiversity loss. [New York Science Journal. 2009;2(1):1-12]. (ISSN: 1554-0200).

Keywords: Asian elephant, *Elephas maximus*, decline, Rajaji National Park, conservation, India

Introduction

India currently has the largest surviving population of the Asian elephant, approximately 50 % of the total world population of the species (Daniel, 1996). A number of wildlife habitats have undergone or are being threatened with fragmentation due to various anthropogenic factors and this has adversely affected the large mammal populations residing in them (Johnsingh et al., 1990). The status of the elephant in the adjoining countries is equally poor. Nepal, which has the lowest country population, has lost over 80% of its elephant habitat on account of human settlement. Bangladesh, Myanmar, Cambodia, Vietnam, Laos and Sri Lanka are also losing rapidly the natural forest cover, specially the elephant habitats. In Thailand in spite of the elephant having been a protected species since the 18th century, over exploitation of the habitat and the pressure of human population has made the species highly vulnerable (Daniel, 1996).

The Shivalik foothills are one of the world's most spectacular landscapes, encompassing the tall grasslands and the *Shorea robusta* (Sal) forests. This entire belt is natural home of Asian elephants (*Elephas maximus*) besides many other wild animals like *Panthera tigris* (tiger), *Panthera pardus* (leopard), *Melursus ursinus* (Sloth bear), *Hyaena hyaena* (Hyaena), *Muntiacus muntjak* (Barking deer), *Axis axis* (Spotted deer), *Cervous unicolor* (Sambhar), *Sus scrofa* (Wild boar) and *Ophiophagus hannah* (King cobra). The Rajaji National Park was established to enhance the long-term survival of the Asian elephant in a sub tropical moist deciduous forest in India. Recently, human exploitation and habitat destruction have caused major decline in the abundance of the terrestrial megafauna. As most of the wild animals are presently categorized under threatened category therefore, there is increasing concern that the area-wise decline of the elephant will have unexpected and grave consequences for the long-term viability of the terrestrial ecosystems.

The Rajaji National Park was established to enhance the long-term survival of the Asian elephant in a sub tropical moist deciduous forest in India. But during the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well

as other anthropogenic activities. This situation creates many problems for various organisms living in forests especially for large size mammals like elephant. Genetic isolation, limitation of dispersal, migration and the decline of populations of animals requiring large territories are the most common problems connected with fragmentation of forests and other components of the environment. From conservation point of view Rajaji National Park appears to be India's one of the most successful national park and its development has helped to boost the population of Asian elephant in their natural habitat.

But during the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well as other anthropogenic activities. Human settlements in and around the park area have created the shrinking of elephant's natural paths. The human population around the Raja National Park alone has doubled during past one decade and rapid urbanisation and industrialisation has resulting in the loss of many forestlands to townships and to various development related activities (Joshi and Singh, 2008). A serious threat was also recorded to European wildlife resulting from the dynamic development of a transportation infrastructure network within the Trans-European Transportation Network (TEN-T) programme. This transportation network disrupts migration corridors of large terrestrial mammals and causes a fragmentation of their environment on a scale not previously recorded (Nowak and Myslajek, 2005).The present study was a part of our long term study on the behavioural biology of Asian elephant in north-west India.

Methods

Study Area

Rajaji National Park [29^0 15' to 30^0 31' North Latitude, 77^0 52' to 78^0 22' East Longitude] is spread over an area of 820.42 Km^2 in and around the Shivalik foothills, which lies in the lesser Himalayas and the upper Gangetic plains (Figure 1). Spread across Hardwar, Dehradun and Pauri districts of Uttarakhand state, Rajaji National Park (RNP) has been designated as a reserved area for the "Project Elephant" by the Ministry of Environment and Forests, Government of India with the sole aim of maintaining the viable population of Asian elephants in their natural habitat. The Shivalik foothills offer the most prominent geomorphic features of this tract. The river Ganges has cut across these hills at Hardwar. The Chilla forest area of the RNP lies in the east of the river Ganges and is attached by the Garhwal Forest Division. The study is ongoing in Hardwar (District-Hardwar), Chilla (District-Pauri) and Motichur (District-Dehradun) forest ranges of the RNP. Besides, few of the adjoining forest areas (Shyampur forest range of the Hardwar forest division) were also incorporated in this study. The altitude lies between 302-1000 m asl. This protected area in India's lesser Himalayan region falls under sub tropical moist deciduous forest type with extensive stands of *Shorea robusta* (Sal), *Mallotus phillipinensis* (Rohini), *Acacia catechu* (Khair), *Adina cordifolia* (Haldu), *Terminalia bellirica* (Bahera), *Ficus bengalensis* (Bar) and *Dalbergia sissoo* (Shisham) in its premise besides many other important fodder plant species.

Data Collection

All the field observations were made from March to June and October to January during 2000 to 2001 and 2006 to 2007. It is not possible to observe the elephants during monsoon as the areas are dominated with tall grasses and dry period is the best time to observe the elephants near to water source. For conducting the study on elephant's presence we made all the observations from a vehicle and we adopted the road-strip count method (Hirst, 1969; Santiapillai et al., 2003) to monitor the fluctuations in elephant numbers. The study area was visited at weekly intervals during which observations on elephants were made along a 6 kilometer stretch of motorable forest track, adjoining to forest habitat. Few other connected rough routes, which link the grassland habitat with motorable road were also used during the course of study. As few forest beats of the Hardwar forest does not comprises of any road, therefore, study was made on foot. Although some animals were observed upto a maximum distance of 100 meter, most of the observations fell within 50 meter. Besides, all the potential habitats (water dominant areas, cool shaded areas, fodder enriched areas and rough forest routes) were also investigated on foot during early morning, mid-day and evening hours. Cool shaded trees like *Ficus bengalensis*, *Adina cordifolia* and *Ficus glomerata* and dense forest of *Mallotus phillipinensis* were examined mostly during mid day (March-June) hours as elephants generally take rest under these cover. Whereas all the water sources (perennial/annual) were investigated alternatively during evening hours.

As the elephants in RNP have been known to emerge from the forest predominantly during evenings, all sightings of elephants were made between 1500 hours and 1900 hours. Different forest blocks of concerned forest ranges were selected one after another sequentially and searched for elephants for about 10 – 12 hours (depending upon weather conditions) in a single day search. The observations started at early hours in the morning being the best time to search and observe the elephant in open areas and four hours in the afternoon, before the sunset. The data collected was as part of the animal monitoring activities. The daily record was based on direct sighting of animals, indirect evidences like feeding sign, footprints impression time and fresh dung piles. The direct sighting were noted in duly prepared observation sheet, recording the group composition, age and sex, if observed in groups and also the place of sighting,

time and vegetation type. Field binocular was also used for observing their movement behaviour without disturbing the animal from an adequate and safe distance.

Besides, villagers of adjoining areas, Gujjars (where available), staff of forest department, the workers from various scientific institutions and non-government organizations and other individuals working on this problem, were also interviewed. Identification of the elephants is important to verify their movement as in the same area there is a possibility that the same group was observed in the different forest beats. Therefore, distinctive features, with certain identification marks of individual elephants were noted like; shape of the ears, tusk size and shape, scars and tubercles on the body, tail length, total number of individuals (all ages separately), body mass and nature of group or solitary bull. For census purpose, the four categories recognized by Eisenberg and Lockhart (1972) – namely adult, sub adult, juvenile and calf were adopted.

Results

During 2000 and 2001, a total of 91 recognised elephants were sighted whereas during 2006 and 2007 only 31 elephants were observed in the study area (Figure 2). Adult and sub-adult females were accounted for highest number 54 – 59.3% (2000-2001) and 18 – 58.06% (2006-2007) while, calves represented the lowest number (9 – 9.8%, 2000 and 2001 and 3 – 9.6%, 2006-2007). 12 – 13.1% (2000-2001) and 5 – 16.1% (2006-2007) represented solitary adult or sub-adult males and juveniles represented 16 – 17.5% and 5 – 16.1% during 2000-2001 and 2006-2007 respectively. And as per the field observations and available data it seems that population composition of the elephants was almost same during both the study periods but their number has decreased to three folds since last seven years. A study on 42 classified groups of elephants (n=378) gives the relative proportions of the adults, sub-adults, juveniles and calves to be 214 (56.6%), 87 (23%), 58 (15.3%) and 19 (5%) respectively (Joshi et al., 2007).

Elephants have suffered most grievously as compared to other wild herbivores on account of loss of their natural habitats and corridors as they require larger space. Increasing human pressure inside the deeper forest regime and developmental projects has given rise to management and conservation problems. These include crop raiding by elephants outside the protected area and even some human fatalities. The human population around the RNP alone has doubled during past one decade and rapid urbanization and industrialization has resulted in the loss of many forestlands to townships and thereby increasing the major problem during the recent past. Presently RNP is a natural home to about 418 elephants (Figure 3 & 4) and few of its forest ranges has helped to enhance the population of elephants but the population of elephants was continues to decline in Hardwar forest range of the RNP mainly due to biotic pressure, developmental activities, presence of railway track and national highways. Since 1987, 19 elephants were died in Hardwar forest range due to various reasons (Table 1) and it was observed that the status of elephants' movement in this forest was continuing to decline.

1. Utilization of Forest Products

Collection of fuel-wood by villagers was one of the major problem, as they sometimes fell down the juvenile trees or shrubs. During the recent past, grazing of the cattle's and lopping of fodder species by Gujjars (nomadic community) within the park area during the recent past has caused serious effects on the regeneration potential of many fodder species like *Shorea robusta* (Sal), *Ficus benghalensis* (Bar), *Emblica officinalis* (Amla), *Anogeisus latifolia* (Bakli), *Terminalia belerica* (Bahera), *Terminalia tomentosa* (Sain), *Oogeinia oogenensis* (Sandan), *Garuga pinnata* (Kharpat), *Bauhinia variegate* (Kachnar), *Schleichera oleosa* (Kusum) and *Lannea coromendelica* (Jhingan), which are crucial for frugivorous birds and mammals. Collection of non-timber valuable forest production like *Eulaliopsis binata* (Bhabar grass), *Kydia calycina* (Pula), *Neyraudia arundinacea* (Bichla grass), *Dendrocalamus strictus* (Bamboo) and *Aegle marmelos* (Bel) with leaves are also the causative agents for decline in the population of elephants. Presently Gujjars are relocated outside the park area as per the directions of Honorable Supreme Court of India and in few of the ranges settlement programme is still ongoing. In RNP Gujjar rehabilitation programme has provided the better opportunity for livelihood to pastoral Gujjars and on the other hand it has promoted the regeneration of forest wealth along with movement related activities of wildlife (Joshi and Pande, 2007).

2. Biotic Pressure

There have been cases of loitering in the park area without permission probably such people are of questionable identity and are responsible for acts of poaching. These types of anthropogenic activities are more commonly seen in those areas, which are attached to park boundary. Several times it was also observed that many people enter to the park area and indulged in nefarious activities. Sometimes they were observed to play cards, booze, roam here and there, burst crackers and throw stones to deter away the elephants. Religious places like Goddess Mansa devi temple, Sureshwari devi temple and Bilkeshwar temple are also situated inside the Hardwar forest range and the visiting devotees and workers of the temples sometimes hinder elephant's movement. There are many instances when religious banquets on large scale are organised and hoards of visitors disturb elephants that come to drink water in the

evening hours. More than 6-7 lacs people visit Mansa devi temple every year. During last decades the general economic condition of people has bettered, this has leaded to increase in the purchase power, social interactions, tourists and religious activities of the people at all levels (Joshi and Joshi, 2006).

In other temples more than 50,000 people visit annually and the crowd was seen especially during the Shivratri and Sawan Purnima fairs. In 2007 about 25 lacs people visited on the occasion of Sawan Purnima in July. It was observed during the study period that in few of the places elephant's activities has changed, which has caused irregularity in their natural activities. Dudhia forest beat due to its proximity to the Haripurkala village and river Ganges is one of the most sensitive area as far as elephant casualties are concerned. Occasionally, the movement of only solo bulls was observed in this part of the park but group movement was almost restricted in this forest pocket. Dudhia forest is having huge amount of *Dalbergia sissoo* (Shisham) and *Acacia catechu* (Khair) forest, the preferred food item of the elephants. Besides, few of the grass species like *Saccharum munja* and *Desmostachya bipinnata* were also grow in profusion in this area. Generally, the solo adult bulls follow the city route for visiting to Dudhia forest and river Ganges through crossing the railway track and Hardwar–Dehradun National Highway.

Elephants enter to the city from northern Kharkhari forest beat and moves towards Chilla forest after the sunset and re-enter to the northern Kharkhari forest before dawn. During this long journey of about 2 kilometer elephants have to cross many of the minor routes along with various human habitation areas. Sometimes solo bulls from Chilla forest also enter in this forest through crossing the island in between the river Ganges. This track falls under Chilla – Motichur corridor and is one of the important habitat as far the elephants' conservation is concerned. Before 1998 elephant groups were known to cross this track for performing their long-term migration towards Corbett National Park area. Similarly, other forest beats of Hardwar forest range were also attached with human settlements.

3. Hardwar – Dehradun Railway Track

Presence of railway track, which passes in between the RNP area (Hardwar – Dehradun railway section) is one of the major obstacle in elephants' long-term migration and frequent movement within their home range. A total of 19 elephants are killed due to train accidents since 1987 besides many other wild animals like leopard, spotted deer, sambhar, python, porcupine, peacock and jungle fowl (Table 2). This track is 16 kilometer long and comprises of sharp bends through which train drivers are unable to see the elephants from a safe distance and most of the accidents were occurred during night hours and in dry season (Joshi and Joshi, 2000). Train accidents mainly occurred during the dry season when the availability of natural water was scarce. This also coincides with a thick and rich harvest of the Rohini (*Mallotus philipinensis*) trees, available in rich amount adjoining to the railway track. This is favourite food item of the elephants in this part of the park. *Mallotus phillipinensis* was also present in the eastern side of the track, and for feeding on these the elephants cross the track mainly around the sunset and return back in the early morning hours. Most of the unnatural deaths of the elephant occurred during night, while these were moving in groups. During the night train drivers are unable to see the object from a safe distance as the head lights of the engine can penetrates only up to the distance of 100 meters (depends upon climatic conditions).

4. State Infrastructure and Industrial Development Corporation of Uttarakhand Limited

After separation of the Uttarakhand from the Uttar Pradesh state (2000), Hardwar city became the industrial area of the state, which was named as State Infrastructure and Industrial Development Corporation of Uttarakhand Limited (SIDCUL) and adjoining area (2034 Acres) of the Hardwar forest range was acquired for development of SIDCUL. Since 2002 rapid expansion of industrial area has caused obstruction in frequent movement of elephants besides many other wildlife in adjoining forest area. Before 2002 tiger movement was frequently observed in few of the forest pockets but presently has got restricted. As the result of establishment of more than a dozen of industries, demand for water has been increasing and to meet the demand ground water is being extracted by various stakeholder industries and that has caused the major impact on ground water of adjacent areas. Besides, industries are frequently discarding their effluent to the ground because of absence of any appropriate outlet for discharge of waste material.

5. Shrinking of Perennial Water Sources

Hardwar forest comprises of many wells those were constructed before the declaration of park area with the aim of maintaining the water availability especially during dry months. Historical evidences suggested that these wells are constructed before 1877 and adjoining to forest roads and raos (seasonal water streams). It was observed that the water level has decreased in all the wells. According to our measurements, about 1.5 meter of the water level has decreased during the last 4 years. This area is currently facing the scarcity of water and fodder species as far the elephant presence is concerned. Most of the perennial water sources (Ranipur water stream in Ranipur forest beat, Bagro, Sukro, bara pani and chota pani in Kharkhari forest beat and hathi kund in Bilkeshwar forest beat) have shrinked presently, whereas before 2002 all of these water sources were fulfilled with tremendous water (Table 3). Similarly, Nauranga water pond in Kharkhari forest beat, Dhak and Jhabri water sources in Mayapur forest beat and Harnol

water source in Harnol forest beat have shrinked completely whereas before 2001 elephants have utilized these sources throughout the year as this forest is an connecting corridor for elephant movement towards Motichur, Kansro and Dholkhand forest range.

6. Forest Fire

Forest fire was one of the most important factor, which has forced the elephants to move out of this forest range. As per available records about 15 hectares of Kharkhari forest was destroyed during 2007 mainly due to forest fire. Again in March and April 2008 about 7 hectare of Kharkhari and Ranipur forest was burned due to fires. It was observed after examining the situation that all of these fires were originated due to human beings. A total of 146 annual fires in RNP area in between 1996-2002 has affected 540.71 hectare of forest cover (Management plan of the Rajaji National Park). Study revealed that many of the important fodder species were affected along with grasses and animal leave the area for a long period of time.

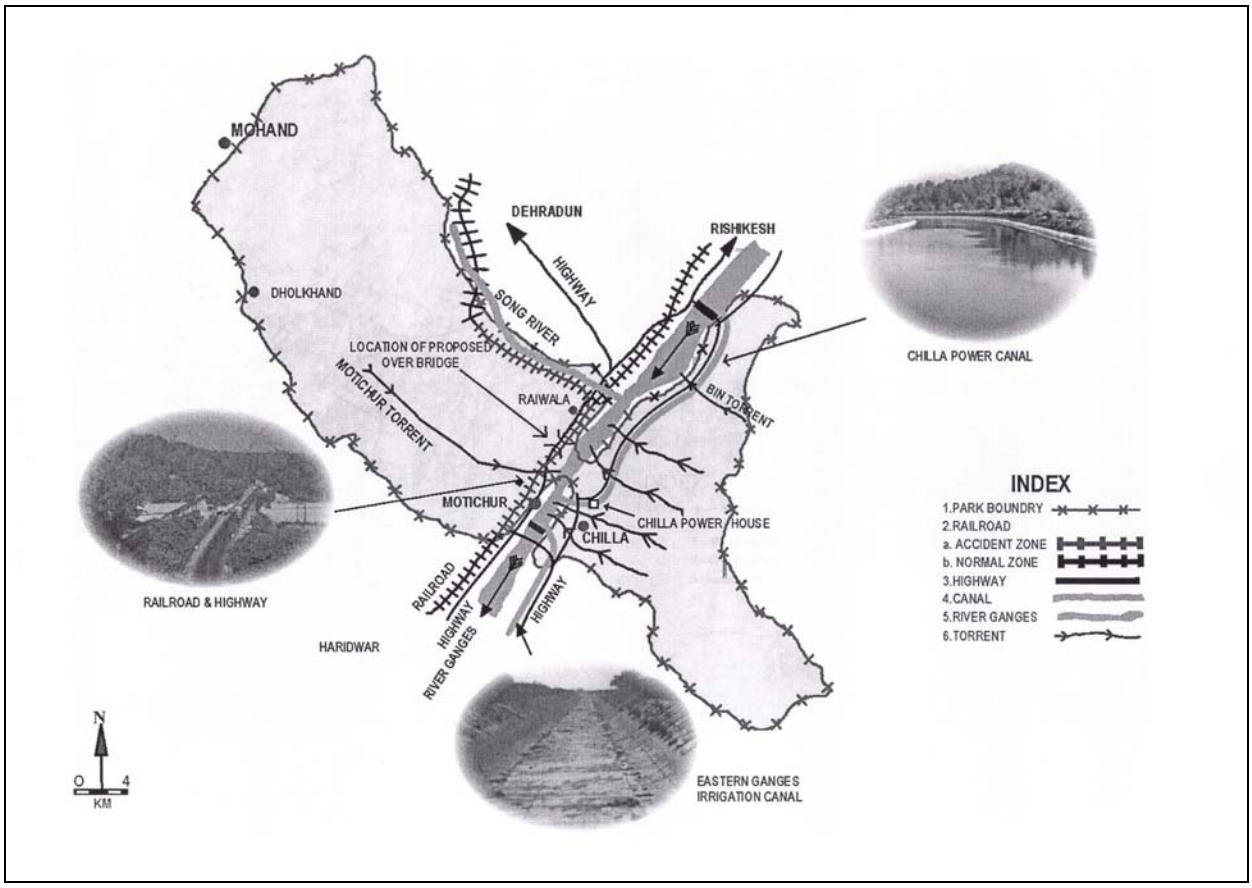

Figure 1. Map of the study area.

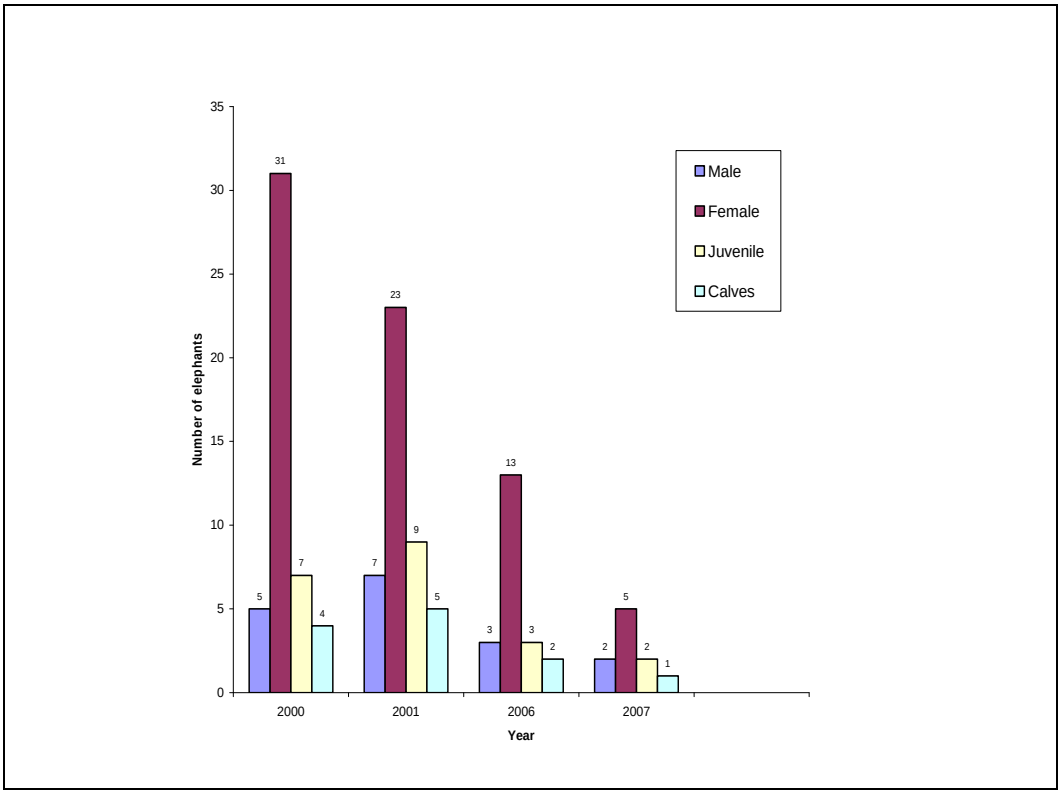

Figure 2. The composition of the elephants in Hardwar forest range of the Rajaji National Park during 2000, 2001, 2006 and 2007

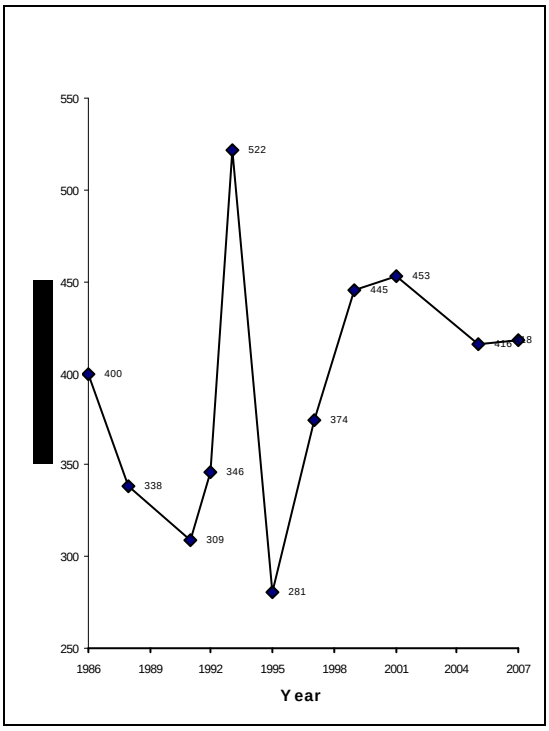

Figure 3. Showing Elephant Population in the Rajaji National Park since 1986.

Figure 4. Elephants at Hardwar forest of the Rajaji National Park.

Fig.3. The composition of the elephants in Hardwar forest range of the Rajaji National Park during 2000, 2001, 2006 and 2007

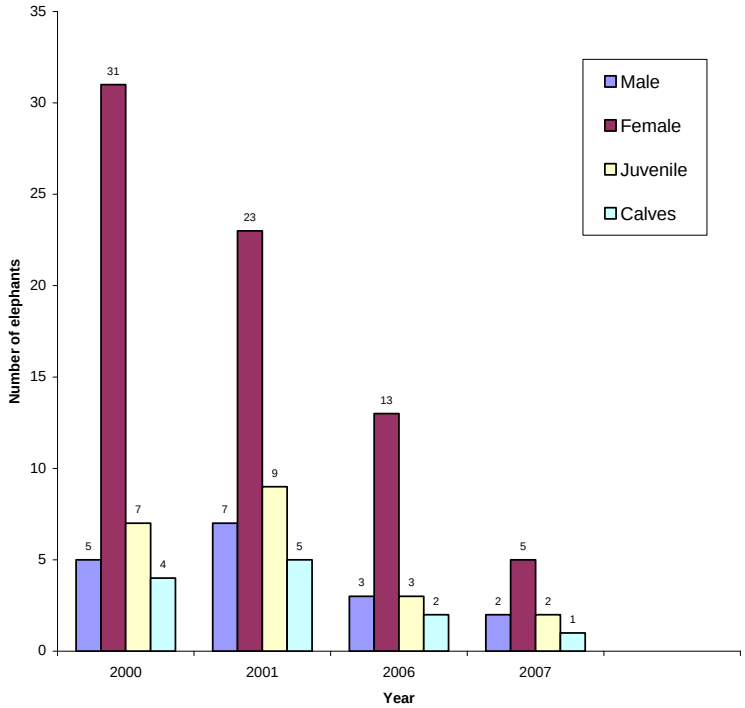

Figure 3. Showing elephant population in the Rajaji National Park since 1986.

Table 1. Elephant's deaths in Hardwar forest range of the Rajaji National Park since 1987.

S. No.	Date of death	Forest range / beat	Animal details	Reason
1.	16.01.88	Hardwar, Kharkhari	Female, 21 years	Electrocution
2.	15.02.87	Hardwar, Kharkhari	Male, 02 years	Falling through hillock
3.	05.10.90	Hardwar, Kharkhari	Female, 12 years	Electrocution
4.	07.11.90	Hardwar, Kharkhari	Female, 15 years	Electrocution
5.	04.12.90	Hardwar, Kharkhari	Female, 01 year	Falling through hillock
6.	02.05.92	Hardwar, Kharkhari	Female, 45 years	Train accident
7.	02.05.92	Hardwar, Kharkhari	Male, 04 years	Train accident
8.	02.05.92	Hardwar, Kharkhari	Female, 45 years	Train accident
9.	02.05.92	Hardwar, Kharkhari	Female, 40 years	Train accident
10.	14.11.93	Hardwar, Kharkhari	Male, 30 years	Bull fighting
11.	18.11.93	Hardwar, Kharkhari	Female, 32 years	Falling through hillock
12.	23.02.96	Hardwar, Harnaul	Male, 65 years	Natural
13.	01.01.98	Hardwar, Rawli	Male, 80 years	Natural
14.	13.03.99	Hardwar, Kharkhari	Male, 11 years	Falling through hillock
15.	02.05.00	Hardwar, Kharkhari	Female, 18 years	Train accident
16.	27.04.01	Hardwar, Kharkhari	Female, 35 years	Natural
17.	29.05.01	Hardwar, Kharkhari	Female, 18 years	Train accident
18.	25.01.02	Hardwar, Kharkhari	Female, 35 years	Train accident
19.	12.03.02	Hardwar, Kharkhari	Male, 03 years	Train accident

Source: Management plan of the Rajaji National Park (2000-01 to 2009-10).

Table 2. Train accidental deaths of elephants in the Rajaji National Park area since 1987.

S. No.	Date	Place / Range where death occur	Animal detail	Approximate time and train	Remarks
1.	April 28, 1987	Motichur / Motichur Range	Female / 13 yrs.	10.00 p.m. / Mussoorie Express	Crushed by train
2.	Mar. 16, 1988	Motichur / Motichur Range	Female 30 yrs.	02.18 a.m. / Goods Train	Crushed by train
3.	Feb. 24, 1989	Kansrao / Kansrao Range	Male / 04 yrs.	08.45 p.m. / Doon Express	Crushed by train
4.	Jan. 01, 1992	Johra / Motichur Range	Female / 80 yrs.	05.30 p.m. / Hardwar – Rishikesh	Crushed by train
5.	May 02, 1992	Kharkhari / Hardwar Range	Female / 45 yrs.	Passenger	Crushed by train
6.	May 02, 1992	Kharkhari / Hardwar Range	Male / 04 yrs.	02.10 a.m. / Goods Train	Crushed by train
7.	May 02, 1992	Kharkhari / Hardwar Range	Female / 45 yrs.	02.10 a.m. / Goods Train	Crushed by train
8.	May 02, 1992	Kharkhari / Hardwar Range	Female / 40 yrs.	02.10 a.m. / Goods Train	Crushed by train
9.	Nov. 22, 1992	Motichur / Motichur Range	Female / 35 yrs.	02.10 a.m. / Goods Train	Crushed by train
10.	May 10, 1994	- / Kansrao Range	Male / 08 yrs.	10.00 p.m. / Goods Train	Crushed by train
11.	May 17, 1994	- / Motichur Range	Male / 55 yrs.	08.40 p.m. / Doon Express	Crushed by train
12.	Sep. 28, 1998	Suswa / Kansrao Range	Female / 35 yrs.	07.50 p.m. / Ujjain Express	Crushed by train
13.	Sep. 28, 1998	Suswa / Kansrao Range	Female / 06 yrs.	07.50 p.m. / Janta Express	Crushed by train
14.	Sep. 28, 1998	Suswa / Kansrao Range	Female / 01 yrs.	07.50 p.m. / Janta Express	Crushed by train
15.	Apr. 03, 1999	- / -	- / -	10.30 p.m. / Mussoorie Express	Crushed by train
16.	May 02, 2000	Kharkhari / Hardwar Range	Female / 35 yrs.	- / Mussoorie Express	Crushed by train
17.	June 04, 2000	Gular Parao / Motichur Range	Male / 08 yrs.	09.40 p.m. / Doon Express	Struck with train
18.	May 29, 2001	Kharkhari / Hardwar Range	Female / 35 yrs.	10.10 p.m. / Mussoorie Express	Struck with train
19.	Jan. 25, 2002	Kharkhari / Hardwar Range	Calf / 02 yrs.	10.30 p.m. / Mussoorie Express	Struck with train
20.	April, 2007	Kharkhari / Hardwar Range	Sub-adult / -	05.15 a.m. / Goods Train 09.45 p.m./ Doon Express	Hit with train (status not known)

Source: Office, Director, Rajaji National Park.

Table 3. Natural water sources in Hardwar forest range with their status during 2000-2001 and 2006-2007.

S. No.	Name of water source	Forest area	Perennial/Annual	Status during 2000-2001	Status during 2006-2007	Current status
1.	Naraunga	Kharkhari	Perennial	Fulfilled with water	Dried	Dried
2.	talab	Kharkhari	Perennial	Running water	Less water as compared to 2000-2001	Only one water point was present
3.	Bada pani shroath	Kharkhari	Annual	Small water bodies at short distances	Water present only in internal zones	Dried
4.	Sukh rau shroath	Kharkhari	Annual	Water available because of	Water points has got decreased	Shrinking
5.	Bag rau	Mayapur	Perennial	ground water seepage Small water points available	Water is continues to shrink	Shrinking
6.	shroath	Mayapur	Perennial			Dried
7.	Gaurikund	Mayapur	Perennial	At 2 points water available At 4 point water available	Shrinked Only 1 water body present,	Shrinking
8.	mandir	Mayapur	Perennial		unpurified	Shrinking
9.	shroath Dhak shroath	Bilkeshwar	Perennial	Water in small quantity available	Shrinked Water sources shrinked,	Shrinking
10.	Jhabri shroath	Rawli	Perennial	Water available in between	water present only during	Water available
11.	Aam shroath	Chirak	Annual	hillock ridges Tremendous water was present	monsoon Water present but	Water available in less amount
12.	Hathikund	Harnaul	Annual	Water present at short	fragmented	Water available in
13.	jamun shroath	Ranipur	Perennial	distances	Water present in very less quantity	internal zones Shrinking
14.	Rawli rau	Ranipur	Perennial	Sufficient water was present		Water available
	Aandheri shroath			Unpurified water was present	Less water was present	but in less amount
	Harnaul rau			Water was available through out the year	Shrinking Water shrinking and dried during hot periods	
	Mittha shroath Ranipur rau					

Discussion

A large mammal like the elephant could be expected to move more considerable distances even with a short period and families of a clan seemed broadly coordinated in their seasonal movements (Sukumar, 1989). In the dry months (January to June), when no rainfalls occur, the groups seek the neighbourhood of streams and shady forests. From the month of July, after the first shower, they start roaming and feed on the fresh grass and this grass in hill tracts become long and coarse by July and August, the elephants then show their upward movements. The reason for the elephants and other animal's migration is the high lands, continuous and uninterrupted hilly terrain for grazing, assured food and ideal breeding ground (Sinha, 1981).

Ranipur, Ravli and Chirak forest beats of the Hardwar forest range are historically famous for *Dendrocalamus strictus* (Bamboo) and due to the presence of huge amount of bamboo patches elephants utilized these forest pockets throughout the year before 2002. It was observed during the course of study that from last 3-4 years the regeneration potential of the bamboo was decreasing continuously. Besides, over feeding on bamboo bushes by elephants has led to destruction of this species. Elephants are a great menace to the bamboo crops and cause considerable damage. In 1950s the bamboo damage through elephants was not so serious in this area but reported to be gradually increasing, therefore, at that time, park managers recommended that the damage should be minimize elsewhere if necessary by effective artificial barriers (Singh and Sibtain, 1959). Forest fires during the last three years have also restricted the frequent regeneration of bamboo in this area. Sometimes villagers are also found responsible for damaging bamboo as they uproot whole of the plant body along with nodes/roots to fulfill their energy requirements.

Another major impact on the conservation of the elephant was forest fire. The periods from mid-March to June are the most fire prone season and this fire may be of natural or of anthropogenic origin. Sometimes, burning cigarettes, biddies, matchsticks and electric fence are the causative agents of forest fire but sometimes this fire also took place naturally. During very period when the upper surface of the land is too much hot the dry grasses like *Eulaliopsis binata* due to highly flammable nature sometimes catch fire on account of minor negligence of human beings around. Few of the villagers are also responsible for this fire because they think that after burning of old vegetation new seedling of the trees come up quickly. During March 2007 forest fire has destructed about 15 hectare forest of Kharkhari and our assessment just after the fire concluded that all the wild animals' even herbivores has leaved the forest for few months. About 7 hectare of Ranipur and Kharkhari forest was also damaged due to forest fire during

March and April 2008 and both of these areas are very crucial as far the movement of elephants during monsoon is concerned. These fires may cause irregularity in the movement pattern of elephants and their movement could be increased towards adjoining forests and human habitation areas. The reasons for migration of elephants can be annual fire, drought, non-availability of fodder, paucity of drinking water and absence of cool green shades in their respective areas (Ramachandran, 1990). Stray behaviour among elephants in adjoining areas of the RNP has been more common from last two years as compared to previous years (Joshi and Joshi, 2001).

Our earlier observations reviews that the declining rate of elephant's population in this area was mainly due to scarcity of natural water and declining rate of fodder species. A total of five villages named Ravli Mehdood, Roshnabad, Aaneki, Aurangabad and Subhash Nagar were attached to the boundary of this forest and over the last 6-7 years rapid expansion of agricultural land and construction activities has also hindered the movement of elephants in this area. The motor roads, which are adjacent to the forests like Hardwar-Dehradun National Highway and BHEL roads have heavy traffic pressure. As per a preliminary study, the average number of vehicles passing on Dehradun-Hardwar road per day is 7,929 and all the wild animals, including elephants, are not in a position to cross this track at any time due to the presence of heavy traffic (Singh and Sharma, 2001). Same situation is with other corridors present adjacent to the RNP area. Kotdwar – Lansdowne road runs parallel to the river Kho and crosses the Rajaji-Corbett corridor, the major movement track of northwestern elephant population between the Yamuna and river Sharda. This road serves as the major transport link between Pauri town and Kotdwar area. The presence of traffic on the road, construction of steep retaining walls by the side of road and the presence of human population along the entire corridor area have almost restricted the migration of elephants using this corridor (Johnsingh and Williams, 1999). Most of the seasonal migratory routes through which elephants performed their long-term migration have been shrinked presently as the result of which elephants of Rajaji are restricted to move only in internal ecological units, whereas bull elephants occasionally were observed to move within such long corridors like Chilla - Motichur and Khara – Anjani (Joshi and Singh, 2007).

In RNP the non-edible shrubs were found to form 57% of the total shrub cover. The main herbs and shrubs are – *Parthenium hysterophorous, Lantana camara, Cassia tora, Cannabis sativa, Pogostemon benghalensis, Sida rhombifolia* and *Ageratum conyzoides*. Most of the wild animals do not feed on these species and on the other hand fast growth of these species has been reducing the fodder composition within the protected area. Weeds like *Parthenium hysterophorous* were more dominant in Motichur forest beat and distributed all over the site. In the month of October and November it shows flowering as well as fruiting stage, while in the month of December and January, it was in seed dispersal stage (Joshi et al., 2000).

The factors that contribute to the killing of humans by elephants are the presence of people into elephant's habitat to collect firewood and fodder, conflict over water and cultivation of palatable crops near the forest boundary. In between years 1986 to 2004, elephants have killed 47 persons and injured 43 persons in and around the Rajaji National Park area. And in Hardwar forest range, elephants have killed 26 persons and injured 11 persons in between year 1985 to 2001.

Before 2002 groups of elephants have been observed frequently in different forest beats of the Hardwar forest range. Kharkhari forest is traditionally one of the important habitat of elephants as this area lies in Motichur-Chilla corridor – the major corridor for elephant movement from Rajaji to Corbett National Park area. Another important factor of elephant presence in this forest during hot period is the presence of tremendous amount of *Mallotus phillipinensis* (Rohini) trees, which is the favourite food item for elephants (Table 1). In few of the streams (Ravli and Ranipur) internal core zone parts were always fulfilled with natural water but due to lack of fodder species elephants are not utilizing these forests. Presently, elephant's movement is quite rare in all of the forest beats of the Hardwar forest range. Only solo bulls and sometimes small groups of 3-7 elephants were reported to move within this forest stretch. As per our review of the study, elephants start utilizing this forest area at the onset of monsoon (from the month of July), when due to extreme rains all the water bodies get filled with tremendous water leading to spontaneous regeneration of the fodder species along with natural vegetation of the area. Besides, bamboo seedlings also start growing considerably in this part of the park.

Recommendations

1) For controlling heavy traffic between Haridwar and Raiwala, there is a need of a fly-over, which will help in reducing the road accidental deaths of wild animals and which makes them to move freely within the Motichur – Chilla corridor. There is also need to convince the local people and tourists not to feed wild animals in the forest stretch, which also attracts elephants, to feed on the remains.
2) Strengthening of the Chilla –Motichur corridors.
3) Islands on the river Ganges (including Dudhia forest beat of Hardwar forest range) should be restored and freed from any anthropogenic disturbances.
4) Traffic should be stopped in the Hardwar – Jwalapur bypass road during evening hours.

5) Artificial water holes must be created, spread within the park area at short distance. For solving the problem water uplifting pumps can be used to uplift the well water during day hours, which will help during hot periods.
6) As the park area mainly comprises of Dehradun and Hardwar region, so it is proposed that the time of the night trains be shifted approximately half an hour earlier than the present schedule time. By employing this method the train could be made to move slowly and can be easily stopped in emergency, through the park area up to Hardwar.
7) Few of the sub-way (elephant under path way) may be constructed on the sharp places from where elephants cross the railway track and the national highway.
8) The foothills near the track must be widened and cleared for better and distant visibility of the train drivers as well as for the wild animals.
9) The people those are roaming here and there in the national park area especially in those forest beats, which are attached to human habitation should be stopped. Besides, construction work, which was ongoing in adjoining areas of the park boundary should be regulated to some day hours.
10) A better management strategy / action plan will be needed to control the unwanted activities from the industrial estate.

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Genomic DNA Extraction Methods from Wormwood Capillary (*Artemisia capillaris*) for PCR-RAPD Studies

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ABSTRACT: The protocol evaluated included the Sarkosyl Method, Kit Wizard™ Genomic DNA Purification (Promega), CTAB method, Sodium Dodecyl Sulfate (SDS Method) and Phenol-Chloroform Method. All five protocols evaluated effectively to isolate the DNA from each of the six samples and produced consistently positive results. The quality and quantity of the DNA extracted was compared using UV-spectrophotometer. It was found that the use of Sarkosyl method had good quality among others method (mean 1.4211). However, the CTAB method resulted in the most consistently positive results at the lowest concentrations (mean 795.83 ng). DNA was successfully isolated and RAPD was effectively used to study genetic similarity among *Artemisia capillaris*. [New York Science Journal. 2009;2(1):13-21]. (ISSN: 1554-0200).

Key words: *Artemisia capillaris*, genomic DNA isolation, SDS, CTAB, Sarkosyl, RAPD.

INTRODUCTION

Artemisia capillaris is a species from class Magnoliopsida and family Asteraceae. *Artemisia capillaris* also know as wormwood or wormwood capillary in European (ShamanShop.net, 2002), Yin Chen Hao in China (ShamanShop.net, 2002; Dharmananda, 2002) and in common names are Pokok Ru Nyamuk and Pokok Daun Ru. *Artemisia capillaris* is a member of the parsley family, is a strong-smelling, fennel-like, annual plant reaching a height of about 4 feet or more. *Artemisia capillaris* leaves are alternate, basal large and petiolate, upper often subsessile to sessile, undivided or toothed-shallowly to deeply incised or lobed, palmati or pinnatipartite or pinnatisect. The Flowers is yellowish and tubular. Ray-florets: pistillate and fertile; corolla narrowly tubular, generally tapering upwards, toothed, oblique, eligulate; style exserted, 2-cleft, branches recurved, linear-filiform and terete-oblong, flattened (eFloras.org, 2006). *Artemisia capillaris* was introduced to this country from Asia (Duane and Martha, 2006; Plant for Future, 2006), America and Europe (Duane and Martha, 2006). It is in flower from August to October, and the seeds ripen from September to October for country that had seasonal (Plant for Future, 2002). It is cultivated in China, Japan, Taiwan (ShamShop.net, 2002) and some extent in this country. Small acreages of *Artemisia capillaris* have been grown successfully as a commercial crop.

About 2,000 years before *Artemisia capillaris* has been used in Chinese herbal medicine. This *Artemisia capillaris* considered to be a bitter and cooling herb, clearing "damp heat" from the liver and gall ducts and relieving fevers (Chevallier, 1996). *Artemisia capillaris* widely used in Asia to prevent and treat neonatal jaundice, also effective remedy for liver problems, works on stomach and spleen (Chevallier, 1996; Huang *et al.,* 2003; Abestmall, 2006). Modern research has confirmed that the plant has a tonic and strengthening effect upon the liver, gallbladder and digestive system (Chevallier, 1996). The studied from Hong *et al*., 2004 suggest that *Artemisia capillaries* can be a useful therapeutic agent for endotoxin-induced inflammation and injuries of the liver.

DNA extraction is a routine procedure to collect DNA for subsequent molecular or forensic analysis. Extracted genomic DNA contains nuclear and mitochondrial DNA, if DNA is extracted from plant material it will also contain chloroplast DNA. Each of these types of DNA has forensic, diagnostic and phylogenetic uses, and makes use of the polymerase chain reaction (PCR) to obtain specific information from the DNA. Purified DNA may also be used for studying DNA structure and chemistry, examining DNA-protein interactions, carrying out DNA hybridizations, and for cloning and sequencing (Jimmy and Larry, 2005). The problem of DNA extraction is still an important issue in the field of plant molecular biology. Various plants contain high levels of polysaccharides and many types of secondary metabolites affecting DNA purification (Zidani et al., 2005). According to Henry, (2001) yield and quality of DNA often varies among plant tissue types. Besides, purification of genomic DNA in plant is difficult due to co-extraction of high quantities of tannins, polyphenols and polysaccharides (Shepherd *et al*., 2002). Isolation of plant nucleic acids for use in Southen blot analysis, polymerase chain reaction (PCR) amplifications, restriction fragment length polymorphisms (RFLPs), arbitrary primed DNA amplifications (RAPD, SSR-PCR), and genomic library construction is one of the most important and time-consuming steps (Zidani et al., 2005).

MATERIAL AND METHODS

Sample Collections.

The samples of *Artemisa capillaris* were collected from the area in Kuala Terengganu, Terengganu. 6 samples were collected randomly around this area.

Kit Wizard™ Genomic DNA Purification (Promega)

DNA from *Artemisia capillaris* leave was extracted from the samples by using Kit Wizard™ Genomic DNA Purification (Promega). About 70 mg of *Artemisia capillaris* leave were used for the extraction of the DNA. 600 µl of nuclei lysis were added to the *Artemisia capillaris* leave into 1.5 ml micro centrifuge tube. The mixture then were homogenized to get the lysat. Then the samples were incubated in the water bath at 65°C for about 15 to 20 minutes. After that, it were treated with 3.0 µl of RNase. The samples then were incubated again in water bath at 37°C for 15 to 20 minutes. Next step, the samples were left at room temperature for 5 minutes.

About 200 µl Protein Precipitation (protenase) were added in the samples and then the samples were vortex at highest maximum speed for about 20 seconds. Then the samples were centrifuged at 14,000 rpm at room temperature for 3 minutes. The supernatant that contain DNA were removed to put into a new micro centrifuge which contains 600 µl of isopropanol. The samples were centrifuged once again at 14,000 rpm at room temperature for 2 minutes. Next step is 600 µl of ethanol (70 %) were added to the pellet to wash the DNA. Once again the samples were centrifuged at 14,000 rpm at room temperature for 1 minute. Then the DNA were dried at room temperature for 10 to 15 minutes. Then the DNA were resuspended with 100 µl of "DNA rehydration" for 1 hour. The DNA extraction samples were keep at -20°C to avoid DNA from degradation.

Phenol-Chloroform Method

DNA was extracted based on the Phenol-chloroform method described by Brown *et al.* (1991) with some modifications. Digestion buffer at volume of 500 µl containing (1 % (w/v) Sodium Dodecyl Sulphate 0.8 %, Triton X-100, 0.5 M NaCl, 0.1 M Tris-Hcl at pH 9, 0.01 M EDTA) were added into 1.5 ml microcentrifuge tube which containing 70 mg all snail body tissue and then the 40 µl of 10 % (w/v) SDS and Proteinase K (20 mg/ml solution) were added. The tube was shaken gently and was incubated at 55^0C for 1 to 2 hours. The sample was treated with 25 µl of RNase. Then, the mixture was left at room temperature for 15 to 30 minutes. The sample were treated with 500µl of phenol:chloroform:isoamyl alcohol (25:24:1) and gently the tube were vortexed to homogenize.

The sample was left at room temperature for 10 minutes before doing centrifugation at 13,000 rpm for 5 minutes. The top later is aqueous and were remove and dispersed into the new microcentrifuge tube. The step of adding phenol:chloroform:isoamyl alcohol were repeated twice. The samples were treated with 500 µl of chloroform:isoamyl alcohol (24:1) and were centrifuged at 13,000 rpm for 5 minutes. The upper aqueous layer was mixed with 1 ml of ice-cold absolute ethanol by rapid inversion of the tubes several times. Then, centrifuge at 6,000 rpm for 30 minutes and after that the precipitated DNA were collected at the bottom tubes as a white pellet. The pellet was washed with 500 µl of 70 % of ethanol and was centrifuge at 6,000 rpm for 15 minutes. The DNA was allowed to dry at room temperature. Then resuspended with 100 µl TE buffer (10 mM Tris and 1 mM EDTA, pH 8) for at least 24 hours at room temperature to fully dissolved before proceeding to the next step. This DNA extraction samples will be kept in – 20^0C to avoid DNA degradation.

CTAB Method

The genomic DNA plantlets were extracted with modified CTAB method (Doyle and Doyle, 1987). Appropriately 50 mg of *Artemisia capillaris* leave were grounded with pre-chilled mortar and pestle in liquid nitrogen. The samples were suspended in 800µl of CTAB buffer [2% (cetryltrimethylammonium bromide) CTAB, 100mM Tris pH8, 20mM EDTA, 1.4M NaCl, 2% PVP 40] and 20µl β-mercaptoethanol will be added per 10ml CTAB solution]. Subsequently, an equal volume of phenol:chloroform:isoamyl alcohol (25:24:1) were incubated at 60^oC for one hour. The mixtures were subsequently inverted 6 to 10 times to allow mixing and centrifuge at 12000rpm for 10 minutes. The aqueous phase were transferred into new tube, then 500µl of chloroform:isoamyl alcohol (24:1) were added and centrifuge again at 12000 rpm for 10 minutes. Then the supernatant were transferred into new tube and 750 µl cold isopropanol were added to precipitate the DNA. The tube were gently inverted several times until precipitation occurred, otherwise incubated at -20^oC for one hour or over night, then spin at 12000rpm for 12 minutes. The supernatant discarded and the pallets were washed in 500 µl 70% cold ethanol. The pallets were vacuum dry for 1 to 4 minutes and then were dissolves in 100 µl TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0). The contamination of RNA will be removed by digestion with RNAase (10µg ml^{-1}) for 30 minutes at 37^{o}C.

Sodium Dodecyl Sulphate Method

DNA were extracted based on the Sodium Dodecyl Sulphate method described by Dellaporta *et al.* (1983) with some modifications. About 70 mg leaves sample were used to extraction of DNA. About 500 µl of extraction buffer were added into 1.5 ml micro centrifuge tubes that contain samples. The mixtures were grinded with grinder until the tissue break into small pieces. Then the samples were incubated in the water bath at 65^0C about 1 hour. After that the mixtures were tapping the micro tube gently from time to time. The samples were treated with 2 µl of RNase A. Then, the mixtures were incubated at 37^0C about 30 minute. The samples were added with 170 µl of 5 M potassium acetate and were mixed gently. Next step is the samples were incubated on ice for 20 minutes.

About 600 µl chloroform:isoamyl alcohol (24:1) were added in the samples and then the samples were mixed gently. Then, the samples were centrifuged at 13, 000 rpm for 10 minute. The top layer is aqueous and were removed (600 - 700 µl) into the new 1.5 micro centrifuge tube. The samples were added with 600 µl isopropanol and were mixed gently by inverting. Then, were centrifuge at 13, 000 rpm for 15 minutes and after that the precipitated DNA were collected at the bottom tubes as pellet. The pellet were washed with 500 µl ethanol 70% and then were centrifuged at 13, 000 rpm for 2 minute. After that the DNA were air dry or leave overnight for get only the DNA. The DNA were dissolved in 100 µl dionise water or depends on the pellet size.

Sarkosyl Nitrogen Method

Fresh and healthy leafs were using and were placed them in a mortar. Then, were freeze in liquid nitrogen and the material were crush to a fine powder with a pestle. The powders were added to 3ml of DNA extraction buffer in a fresh mortar and were homogenized. Then, 1 ml phenol were added and were homogenized again. The mixed were transferred to a test tube (with cap), 2 ml phenol were added again and were centrifuged for 5 minute to separate phase. The upper aqueous phase were transferred into new tube. Then, two volume of ice-cool 95% ethanol were added to the aqueous phase for ethanol precipitated DNA and were centrifuged for 5 minutes, 12, 000rpm. Then, the ethanol were pour from tube. Precipitated DNA were washed with ice-cool 70% ethanol. DNA were dissolve in 0.5 ml of TE and 2 µg RNAase were added. Then, were incubated at 37 ^{0}C for 15 to 30 minute. 0.25 ml phenol and 0.25 ml chloroform were added and were shaking well. Then, were centrifuged and the upper aqueous phase were transferred into new tube. Then, two volume of ice-cool 95% ethanol were added to the aqueous phase for ethanol precipitated DNA and were centrifuged for 5 minutes, 12, 000rpm. Then, the ethanol were pour from tube. Precipitated DNA were washed with ice-cool 70% ethanol. Finally, will be dissolve in 0.2 to 0.5 ml of TE.

Agarose Gel Electrophoresis

An aliquot of 10 µl of genomic DNA from each sample was mixed with 2.5 µl of loading dye. Then the mixture was separated by agarose gel electrophoresis through 1.0 % of agarose gel in 1.0 X TBE (10 mM Tris, 1mM EDTA pH 8.0). After that the electrophoresis gel were started at 55 volts for 1 to 2 hours. Next the gel was stained with ehidium bromide (EtBr) for 20 to 30 minutes and then was washed with distilled water for 5 to 10 minutes. Then the gel were done photographing with Image Master VDS.

Measurement of DNA Purity and Quality

The genomic DNA extracted was measured using a UV- spectrophotometer at 260 nm and 280 nm. The purity of DNA was determined by calculating the ratio of absorbance at 260 nm to that of 280 nm.

The average value of pure preparations of DNA and RNA is between 1.8 and 2.0 respectively (Sambrook *et al.,* 1989). The DNA concentration was determined by the formula:

DNA concentration = OD_{260} × 50 µg/ml × dilution factor (Linacero *et al.,* 1998).

Screening of PCR

Operon 10 mers Kit A were used in this study. 20 RAPD primers from Kit A (with 60% - 70% G-C) content were screened from a single individual. Primers that have the basic of sharpness, clarity of the profile and the existence of polymorphism were chosen for further study (D'Amato and Corach, 1997). The amplification were programmed at 45 cycles for 30 seconds of denaturation at 94^{o}C, 30 seconds of annealing temperature at 36^{o}C, 1 minutes of primers extension at 72^{o}C and final extension of 2 minutes at 72^{o}C.

RESULTS

Extraction of DNA

The Genomic DNA was successfully extracted and observed to have impurity. Sarkosyl method had a good result, the purity of DNA (gel) is high and clear banding pattern was obtained in this study. The DNA banding patterns were shown in Figure 1.

Purity and Quantity of DNA

The DNA purity of *Artemisia capillaris* with Sarkosyl Method was ranged from 1.3114 to 1.4655, Kit Wizard™ Genomic DNA Purification (Promega) 1.1429 to 1.1593, CTAB Method 1.3097 to 1.5652, SDS Method 1.3828 to 1.7388 and Phenol-Chloroform Method 0.9823 to 1.0382. The range was estimated quantitatively from the ratio between the reading of absorbancy at 260nm and 280nm ($OD_{260}/_{280}$) in UV-Spectophotometer. Quantity of DNA with Sarkosyl Method was calculated ranged from 106.25 to 1567.5µg/mL, Kit Wizard™ Genomic DNA Purification (Promega) ranged from 1182.5 to 2420µg/mL, CTAB Method ranged from 360 to 1268.75µg/mL, SDS Method ranged from 550 to 1350µg/mL and Phenol-Chloroform Method ranged from 2687.5 to 4798.75µg/mL. The values of the DNA purity and quantity are shown in Table 1.

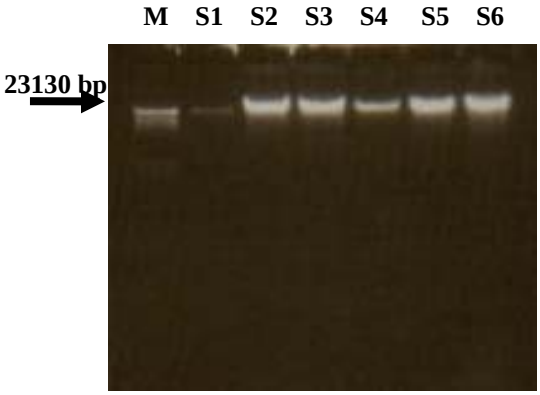
Screening of RAPD Primers

Twenty primers from the Operon 10 mers (Operon Kit A) (OPA 01 to OPA 20) with 60% – 70% GC content were used during the screening of the RAPD primers. The banding patterns which were clear and reproducible bands selected. Photograph showing the RAPD electrophoresis profiles are presented in Figures 2. Out of these, only thirteen of the primers that showed polymorphisms. Number of bands generated by each primer varies, ranging from 0 to 8. Primer OPA 18 formed the highest band number (8). There were 56 fragments generated by these primers (OPA 01 – OPA 20). The sizes of bands were ranged from 250 bp to 1750 bp.

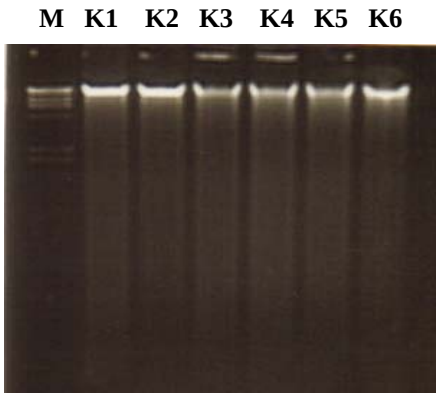
Table 1: Observed density (OD) of DNA purity and quantity of DNA for Genomic DNA extracted (Sarkosyl Method (S1-S6), Kit Wizard™ Genomic DNA Purification (Promega) (K1-K6), CTAB Method (C1-C6), SDS Method (D1-D6) and Phenol-Chloroform Method (P1-P6)).

Sample	OD 260			OD 280			Qualification ratio (Quality)	DNA C (Quantity)(ng)
	1	2	Mean	1	2	Mean		
S1	0.043	0.042	0.0425	0.029	0.029	0.0290	1.4655	106.25
S2	0.627	0.627	0.6270	0.443	0.444	0.4435	1.4138	1567.50
S3	0.452	0.452	0.4520	0.309	0.311	0.3100	1.4581	1130.00
S4	0.359	0.390	0.3895	0.268	0.270	0.2690	1.4480	973.75
S5	0.440	0.438	0.4390	0.307	0.307	0.3070	1.4300	1097.50
S6	0.478	0.478	0.4780	0.365	0.364	0.3645	1.3114	1195.00
K1	0.473	0.473	0.4730	0.408	0.408	0.4080	1.1593	1182.50
K2	0.619	0.619	0.6190	0.537	0.537	0.5370	1.1527	1547.50
K3	0.968	0.968	0.9680	0.848	0.847	0.8475	1.1429	2420.00
K4	0.960	0.961	0.9605	0.835	0.836	0.8355	1.1496	2401.25
K5	0.823	0.823	0.8230	0.714	0.714	0.7140	1.1527	2057.50
K6	0.542	0.541	0.5415	0.466	0.466	0.4660	1.1620	1353.75
C1	0.144	0.144	0.1440	0.092	0.092	0.0920	1.5652	360.00
C2	0.276	0.276	0.2760	0.204	0.203	0.2035	1.3563	690.00
C3	0.507	0.508	0.5075	0.387	0.388	0.3875	1.3097	1268.75
C4	0.272	0.273	0.2725	0.194	0.195	0.1945	1.4010	681.25
C5	0.366	0.366	0.3660	0.262	0.262	0.2620	1.3969	915.00
C6	0.344	0.344	0.3440	0.253	0.253	0.2530	1.3597	860.00
D1	0.352	0.353	0.3525	0.211	0.211	0.2110	1.6706	881.25
D2	0.220	0.220	0.2200	0.130	0.130	0.1300	1.6923	550.00
D3	0.233	0.233	0.2330	0.134	0.134	0.1340	1.7388	582.50
D4	0.316	0.317	0.3165	0.195	0.195	0.1950	1.6231	791.25
D5	0.262	0.263	0.2625	0.164	0.165	0.1 645	1.5957	656.25

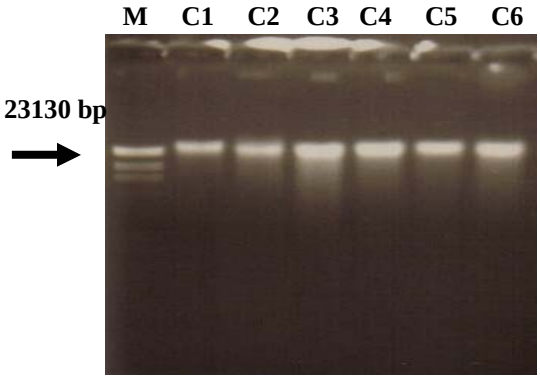
D6	0.539	0.514	0.5400	0.390	0.391	0.3095	1.3828	1350.00
P1	1.880	1.880	1.8800	1.904	1.904	1.9040	0.9874	4700.00
P2	1.577	1.577	1.5770	1.519	1.519	1.5190	1.0382	3942.50
P3	1.075	1.075	1.0750	1.062	1.062	1.0620	1.0122	2687.50
P4	1.904	1.909	1.9065	1.931	1.931	1.9310	0.9873	4766.25
P5	1.909	1.913	1.9110	1.931	1.936	1.9335	0.9884	4777.50
P6	1.922	1.917	1.9195	1.954	1.954	1.9540	0.9823	4798.75



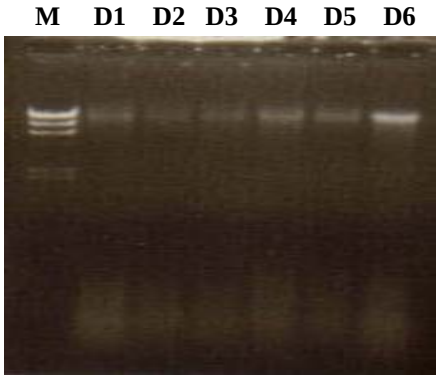
(a)



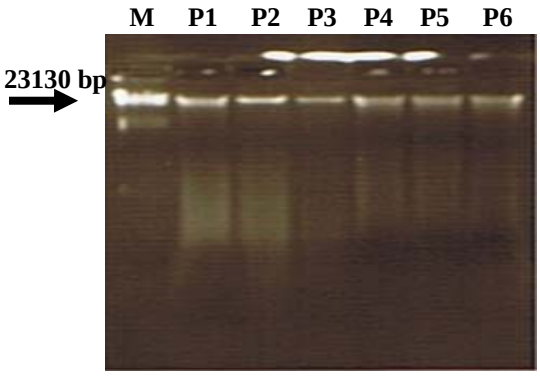
(b)



(c)

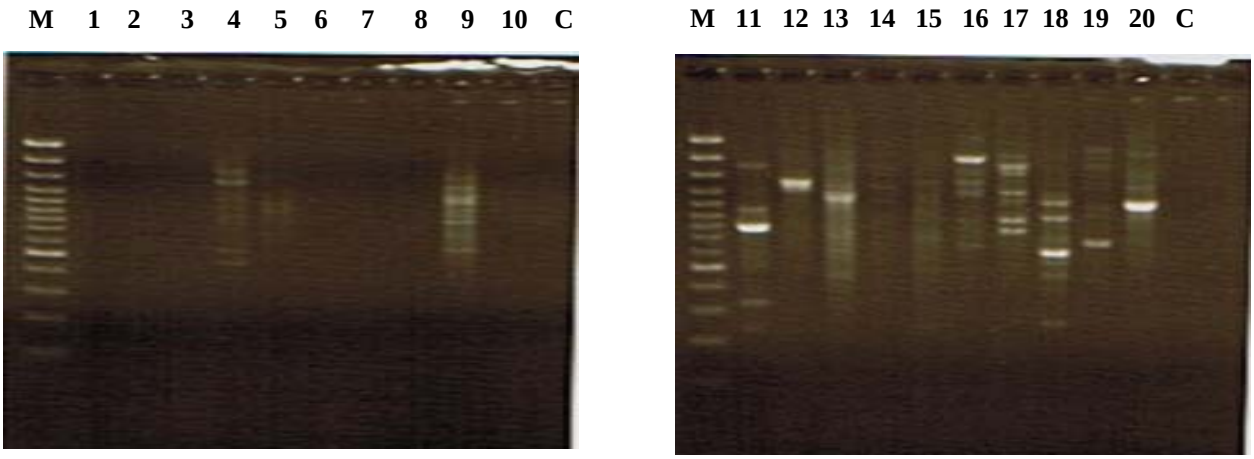


(d)



(e)

Figure 1: Genomic DNA extracted by Sarkosyl Method (a), Kit Wizard™ Genomic DNA Purification (Promega) (b), CTAB Method (c), SDS Method (d) and Phenol-Chloroform Method (e) on 1.0% agarose gel and stained with 1 µg/mL ethidium bromide (EtBr), λ DNA/Hind III marker (lane M) and samples of *Artemisia capillaris* (lane S1 to S6 (a), lane K1 to K6 (b), lane C1 to C6 (c), lane D1 to D6 (d) and lane P1 to P6 (e)).



(a) (b)

Figure 2: RAPD banding patterns for screening of 1st base primers, (a) OPA 01 to OPA 10 (lane 1 to 10), (b) OPA 11 to OPA 20 (lane 11 to 20), (Lane M is a marker 100bp ladder plus, Lane C is a control).

DISCUSSION

Extraction DNA from samples is the first step for all molecular marker type. DNA can be extract either from fresh, lyophilized, preserved or dried samples but for obtaining good quality DNA fresh material is recommended (Semagn *et al*., 2006). There are difficult to get plant DNA free from contaminating proteins and polysaccharides. Different methods need for different plants that contain divers secondary compounds that interfere with the extraction (Croy *et al*., 1993).

The DNA genomic extracted (Figure 1) from method Kit Wizard™ Genomic DNA Purification (Promega), CTAB Method, Sodium Dodecyl Sulfate (SDS Method) and Phenol-Chloroform Method had high of impurity. Sarkosyl method got clean DNA compare other methods. According to Croy *et al*., 1993, most the plants cells had very tough cell wall and make used vigorous method to breaking the cell. The excessive force make the degradation very high molecular weight molecules thought the shearing.

Agarose gel really use for check whether the DNA is degraded or not. Spectrophotometer measures the intensity of absorbance of DNA solution at 260 nm wavelength, and also indicates the presence of protein contaminants but it does not tell the condition of the DNA which is degraded or not (Semagn *et al*., 2006). The quality of the DNA by Sarkosyl Method was better than others methods. The Sodium Dodecyl Sulfate (SDS Method) had good quality but got poor results for gel electrophoresis and had contamination with RNA. So the best result was Sarkosyl Method that had no contamination by protein or polysaccharides and also good in quality. Kit Wizard™ Genomic DNA Purification (Promega), CTAB Method and Phenol-Chloroform Method got poor quality of DNA. The best quality is between 1.8 – 2.0 (Sambrook *et al.,* 1989). None of the methods gave such high values, the range between 0.9823 – 1.7388. The ratio of 1.3144 – 1.4655 by method Sarkosyl Method was used to RAPD analysis (Table 1).

Plants contain three types of DNA like nuclear, mitochondrial and chloroplast DNA (Rudi et al., 1997). All preparation methods for extraction involve the removal of the cell wall and nuclear membrane around the DNA, cell wall debris, proteins, lipid or RNA. Removal of membranes lipids is facilitated by using detergents such as sodium dodecyl sulphate (SDS), Cetyltrimethylammonium bromide (CTAB), mixed alkyl trimethyl-ammonium bromide (MTAB) (Segman *et al*., 2006) and Sarkosyl (Rudi *et al*., 1997).

DNA should be protected from endogenous nucleases and EDTA complexes magnesium ions were included in the extraction buffer that is a necessary cofactor for most nucleases (Rudi *et al*., 1997; Segman *et al*., 2006). DNA extracts often contain a large amount of RNA, proteins, polysaccharides, tannins and pigments. RNAs are removed using RNA degrading enzyme called RNase A in all method we used. For proteins remover, proteinase-K are using in Phenol-Chloroform Method, Sarkosyl in Sarkosyl Method, Protein Precipitation Solution in Kit Wizard™ Genomic DNA Purification (Promega). Phenol also used as removable for proteins. Polysaccharide more difficult to remove, NaCl, together with CTAB is known to remove polysaccharides (Murray and Thompson, 1980; Rudi *et al*., 1997; Paterson *et al*., 1993). Some protocols replace NaCl by KCl (Thompson and Henry, 1995). According to Fang et al., 1992, polysaccharides remain dissolved in ethanol. Chloroform also used for remove polysaccharides.

The separation by centrifuged when DNA with other compounds such as lipids, proteins, carbohydrates, and/or phenols. The DNA precipitated in salt solution with sodium acetate for Phenol-Chloroform Methods, isopropanol for Kit Wizard™ Genomic DNA Purification (Promega), SDS method and CTAB method, and ethanol for Sarkosyl Method. Plant that had high polyphenolic content, can used phenol that work together with SDS to extract it (Puchooa, 2004). But, SDS-phenol tends to produce low yields of DNA (Rezaian and Krake, 1987).

RAPD is one of the genetic marker studies that had been used in genetic study. RAPD technique had been used in genetic study for wheat (Devos and Gale, 1992) and also had used for filogenetic relations for padi species (Ishii, 1996). Chosen suitable primers is very important process for PCR-RAPD to get clear and good band. Twenty primers had been used and amplification showed differences banding pattern (Figure 2). From twenty primers, the best primer was primer OPA 18, because produced clear and sharp banding pattern. Differences primers produces differences fragment pattern. These happened because every primer contents G + C and difference base sequences (parenrengi, 2000). Results showed good PCR-RAPD for DNA extraction from Sarkosyl Method (Figure 2). Similarly, quantity and purity of extracted genomic DNA also plays crucial role for analysis of molecular diversity and optimization of different parameters for PCR (Weeden *et al*., 1992; Staub *et al*., 1996).

CONCLUSION

Sarkosyl Method are the best extraction for *Atemisia capillaris* according to concentration of the extracted DNA from gel electrophoresis (DNA yield and purity) and spectrophotometer (DNA quantity) compare the others method. The screening of primers from DNA extraction (Sarkosyl Method) showed OPA 04, OPA 09, OPA 11, OPA 16, OPA 17, OPA 18, OPA 19 and OPA 20 are suitable primers to use in genetic studies for *Artemisia capillaris*. Based on screening results, Sarkosyl Method is suitable to use in PCR-RAPD studies.

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Urinary Schistosomiasis And Concomitant Bacteriuria In The Federal Capital Territory Abuja Nigeria

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ABSTRACT

Urinary schistosomiasis and concomitant bacteriuria was investigated in the Federal Capital Territory (FCT) Abuja. Single urine samples collected from subjects aged 5 years and above between 1000 hours and 1400hours were examined for the presence of *S.haematobium* eggs using centrifugation technique and for bacteriuria by standard bacteriological methods. A total of 1,150 subjects comprised of 667 males and 483 females were studied from the 6 Area Councils of the FCT. Overall, 360 (31.3%) had the eggs of *S. haematobium* in their urine while 289 (80.3%) of the 360 who had eggs of *S. haematobium* in their urine, had bacterial growth. Prevalence of bacteriuria in urinary schistosomiasis ranged from 74-86% with no significant difference in the distribution of the prevalence of the co-infection in the 6 area councils surveyed (P=0.125). The distribution of bacteria colony count in relation to different ova intensity was significantly different (P<0.001) and assumed a weak positive linear relationship (r=0.2). There was no significant difference in the results of the methods used to investigate for bacteriuria (P=0.05). The bacteria isolated included: *klebsiella species, Escherichia coli, Enterococci species, Staphylococcus aureus, Staphylococcus saprophyticus, Salmonella species, Proteus species, and Pseudomonas species. Eshericha coli* occurred more frequently (70%) than the rest of the bacteria species isolated. The antimicrobial susceptibility pattern of isolates revealed varying percentage susceptibilities by all isolates. This study clearly suggests that bacteriuria is a potent complication in the management of urinary schistosomiasis. Therefore the complimentary incorporation of antibacterial therapy appear essential. [New York Science Journal. 2009;2(1):22-28]. (ISSN: 1554-0200).

Keywords: Schistosomiasis, Concomitant Bacteriuria , Prevalence, Susceptibility,

INTRODUCTION

Urinary tract disease is a specific trait of infection with *Schistosoma haematobium* which affects in a diffuse manner the entire genitourinary tract (King, 2001; Pereira *et al*., 1997). Bacteria infections are often recurrent and important complications of the inactive stage of urinary schistosomiasis which may be instrumental in precipitating renal failure (Farid, 1993). In schistosomiasis of the urinary bladder, secondary bacterial infections are common and in men can involve the seminal vesicles, spermatic cord, and to a lesser extent, the prostate. In women, infection can involve the cervix and fallopian tubes and can cause infertility. Mostafa *et al*., (1999) opined that it seems possible that agricultural workers and others who are regularly exposed to contaminated water are occasionally simultaneously infected with both the schistosome parasite and pathogenic bacteria. The risk factor of agricultural practices the major occupation of indigenous residents of the Federal Capital Territory (FCT) Abuja, Nigeria is capable of breeding urinary schistosomiasis and concomitant bacteriuria. In the light of the relative high level of schistosomal and bacteria infection, active assessment and reporting of bacteriuria in urinary schistosomiasis and the complementary incorporation of antibacterial therapy to the integrated morbidity control approach to urinary schistosomiasis deserves emphasis. This study examined the terminal urine sample of individuals with or without signs of urinary disturbance and infection for evidence of urinary schistosomiasis as well as evaluated associated bacteriological burden and susceptibility pattern of bacteria isolated.

MATERIALS AND METHODS

The study included 1,150 subjects both males and females between the ages of 5-50 years recruited directly through surveillance out-reaches to district/village schools and health related institutions. Informed consent of adult subjects was obtained, while consent to obtain specimen from ‘minors’/pupils

was obtained through parents/guardian and the Education department of the Ministry of the Federation Capital Territory (MFCT) Abuja.

The urine samples were collected between 1000 hours and 1400 hours and were examined for colour, naked eye haematuria, turbidity and these observations were noted. Ten millilitres of urine were transferred aseptically into centrifuge tube and centrifuged for 5 minutes at 5000 rpm (Anosike *et al*., 2001). After discarding the supernatant the entire sediment was transferred to a slide covered with cover glass examined for red blood cells, pus cells (pyuria) and counting of eggs of *S. haematobium*. Using the 10x objective with the condenser iris closed sufficiently to give good contrast, the entire sediment preparation was examined systematically and ova count reported per 10ml of urine (Chessbrough, 1981; Richards *et al.,* 1984).

The remainder of urine samples positive for *S. haematobium* ova were homogenized by inverting the container severally and 0.002 ml of the urine inoculated and spread on Cysteine lactose electrolyte deficient medium (CLED-BIOTEC, UK)and blood agar (Blood agar base-BIOTEC, UK). Afterwards 10ul of the homogenized uncentrifuged urine were applied unto a glass slide allowed to dry without spreading at ambient temperature and stained by Grams method. Using 100x objective the slide was examined for bacteria per oil immersion field (Celso *et al.,* 1998).

The uncentrifuged urine samples were diluted 1:20 (20 ul of urine + 380 ul of Turks solution - 2% Acetic acid tinged with gentian violet).This is to destroy the red blood cells and stain the white blood cell nuclei. The dilutions were transferred to Neubauer haemocytometer chamber. The chamber was examined using 10x objective and 4 squares counted applying the margin rule for including and excluding cell lying on the peripherial lines to quantify pyuria (Campbell *et al.,* 2002). Reagent strip urinalysis was performed using L-Combur reagent strip (Boehringer Mannhein).

The culture plates were examined after 24 hours of incubation for bacterial growth and colony count. Bacteria growth less than 10^5 organisms per ml produced less than 30 colony forming units per ml of urine (Chessbrough, 2000).Bacteria isolates were identified and characterized using methods prescribed by Cowan and Steel,1974; Chessbrough,2000 and Graham and Galloway, 2001. Susceptibility testing of all pathogenic baceteria were performed using the standard disc diffusion method according to British Society for Antimicrobial Chemotherapy (Andrew, 2001).

Statistically Analysis

The data analysis was done using X^2 (chi-square) test to determine significant relationships between variable and coefficient of correlation for test of linearity of relationship.

RESULTS

The overall prevalence of urinary schistosomiasis was 31.1% (95% CI 26.2 – 36.4) in the Federal Capital Territory Abuja and ranged between 25 – 36.3% in the six area councils surveyed. Prevalence followed the typical age group pattern for urinary schistosomiasis attaining a peak 78.4% in subjects 10 – 14 years age, decreasing to 47.6% in subjects ≥ 50 years and lower in subjects within 20 – 39 year. Prevalence of urinary schistosomiasis was higher at all ages in males ranging between 0 – 42.1% and in females 0 – 36.3% (Table1). *S. haematobium* infection prevalence had a statistical significant difference between males and females at different age groups (x^2=48; P<0.001).

In all, of the 360 subjects that had ova in their urine, 275 was positive for uncentrifuged gram microscopy, 305 was positive for pyuria (WBC) count, 330 was positive for leucocytes esterase, 350 was positive for protein, 336 was positive for erythrocytes (urinary blood), 240 was positive for nitrite (Table 2). Overall, 289 samples from subjects had bacteria growth of varying count. 261 (90.3%) samples had overt significant bacteriuria ($\geq 10^5$cfu/ml) in both males and females. Between males and females, there was a statistical significant difference in bacteria colony count in urinary schistosomiasis (x^2=9.9; P=0.025).

Bacteriuria in urinary schistosomiasis in F.C.T. had a prevalence of 80.3% ranging between 74 to 86% in the six area councils of F.C.T. surveyed. Bacteriuria and urinary schistosomiasis co-infection had no statistical significant difference (x^2=9.8; P=0.125).The distribution of bacteria colony count (cfu/ml) according to different ova intensity i.e. egg/10 ml of urine (Table 2); had a weak positive linear relationship (r=0.2). Albeit, there was a significant difference between bacteria colony count and different ova intensity in urinary schistosomiasis (x^2=39.0; P<0.001). The statistical analysis of results from culture and non – culture methods (enhanced microscopic urinalysis and reagent strip tests) for investigating bacteriuria are shown in Table 4. There is no significant difference in percentage positive results of culture and a combination of the non-culture methods for investigating bacteriuria (x^2=5.9; P=0.05). Various bacteria

species were isolated with *Escherichia coli* occurring more frequent than the rest in males (Table 4). Notwithstanding, there was no significant difference in the bacterial isolates between males and females (x^2=7.5; P=0.65)

Antimicrobial susceptibility pattern of bacteria isolates are shown in Table 8. All the isolates had susceptibility in varying percentage to Ofloxacin Ciprofloxacin, Gentamicin and Cefuroxime in order of percentage effectiveness respectively. However all the isolates except 3 were susceptible to Nitofurantion, 2 species of the isolates *(Proteus species and Pseudomonas species)* were not susceptible to Co-trimoxazole while 1 species was not susceptible to Co-amoxiclav.

Table 1: Distribution of the prevalence of S. haematobium infection in FCT according to age and sex; statistical test of significance between make and female

AGE GROUP (YEARS)	**FEMALE**			**MALE**		
	NUMBER EXAMINED	NUMBER INFECTED	% INFECTED	NUMBER EXAMINED	NUMBER INFECTED	% INFECTED
5 – 9	213	93	43.7	120	21	16.7
10 – 14	557	378	67.9	179	65	36.3
15 – 19	200	90	45.0	110	27	24.5
20 – 24	50	38	76.0	12	2	16.7
25 – 29	29	19	65.5	10	1	10
30 – 34	34	13	38.2	21	3	14.3
35 – 39	22	12	54.5	10	2	20
40 – 44	20	8	40.0	12	1	8.3
45 – 49	15	9	60.0	6	1	16.7
>50	10	7	70.0	3	1	33.3
TOTAL	**1150**	**667**	**58.0**	**483**	**124**	**25.7**
X^2_{cal}	***42***	X^2_{tab}	***18.25***			

Table 2: Analysis and statistical test of significance of percentage positively for culture and non culture tests for urinary schistosomiasis and bacteriuria.

NON-CULTURE TESTS				**URINE CULTURE**	
	NUMBER + VE OF 360 EXAMINED/METHOD	% NUMBER . -VE PER METHOD	%	NUMBER + VE PER METHOD	
UNCENTRIFUGED URINE GRAM MICROSOCOPY > 1 ORGANISM/OIL IMMERSION FIELD	**275**	87.3 **35**	76.4	**240**	12.7
PYURIA (WBC) COUNT $\geq 1.0X10^9$	**305**	93.4 **20**	85	**285**	6.6
LEUCOCYTES ESTERASE > 25 LEU/UL	**330**	86 **46**	91.6	**284**	14
PROTEIN > 30 MG/DL	**350**	77.1 **80**	97.2	**270**	22.9
ERYTHROCYTES URINARY BLOOD $\geq$ 10ERY/UL	**336**	86.5 **49**	93.3	**287**	14.5
NITRITE POSITIVE	**240**	84.2 **38**	66.7	**202**	15.8
TOTAL		**514.50%**	**510.20%**		
	X^2_{cal}	***5.5***	X^2_{tab}	***11.03***	
	Pvalue	***0.05***			

Table 3: Distribution of bacteria colony count (cfu/ml) according to different ova intensity (egg/10ml urine); Statistical test of significance and coefficient of correlation in urinary schistosomiasis.

	NUMBER OF SUBJECTS				
BACRERIA COUNT cfu/ml	0-20 (egg/10ml urine)	21-40 (egg/10ml urine)	41-50 (egg/10ml urine)	>50 (egg/10ml urine)	TOTAL
$\geq 10^5$	13	20	10	218	261
10^4	0	3	4	5	12
10^3	3	2	2	3	10
10^2	0	0	2	4	6
TOTAL	**16**	**25**	**18**	**230**	**289**

X^2_{cal}		***39***
X^2_{tab}		***16.92***
Pvalue	***<0.001***	
r		***0.2***

Table 4: Bacteria pathogens associated with *S.haematobium* infection and their antimicrobial susceptibility pattern.

ANTIMICROBIAL AGENT	PERCENTAGE SUSCEPTIBILITY							
Escherichia Species n=101	***Klebsiella coli*** n=30		***Enterococci Species*** n=27	***Staphylococcus aureus*** n=78	***Staphylococcus saprophyticus*** n=19	***Salmonella Proteus Species*** n=11		***Pseudomonas Species*** n= 14
Ciprofloxacin	*98*	89.6	67.5	74	78	68.7	95	61.7
Cephalexin	*25*	38.5	39.2	25	30	16.9	25.4	0
Cefuroxime	*65*	70	67	63	50	46.3	72.5	45
Oxfloxacin	*80.4*	90	85	82.1	80	78	95	8.6
Gentamycin	*76*	82	47	45.9	49.6	85.2	58	70.5
Co-trimoxazole	*26.4*	56	61	68	54	25	0	0
Nitrofurantion	*38.4*	85	65.1	70	64.3	0	0	0
Co-amoxiclav	*32.8*	25	41	33.5	40.2	20.4	63.2	0

DISCUSSION AND CONCLUSION

The findings in this study demonstrates that the overall estimated prevalence of urinary schistosomiasis as determined by ova in the urine was high (31.3%; 95% CI 26.2-36.4%). Recent researchers estimate prevalence of 29.4% in the Eastern Nigeria (Anosike *et al.,* 2001) and 57.4% in the West (Adeyaba and Ojeaga, 2002). The result of this study is agreeable with these reports.

This study evaluated bacteriuria in urinary schistosomiasis revealing that of the 360 subjects (31.3%) who had Ova of *S. haematobium* from 1,150 examined; 289 (80.3%) had bacteriuria by culture characterization. The percentage positive results of culture and a combination of non-culture had insignificant difference (P> 0.05). Though King (2001) noted that urinary tract disease is a specific trait of infection with *S. haematobium*; The 80.3% prevalence of bacteriuria in urinary schistosomiasis need further categorization since by the definition of Gallagher and Hemphil (2004) it may simply be taken as referring to the presence of bacteria in the urine of individuals infected with *S. haematobium* and not necessarily implying infection. This is cogent as bacteriuria and urinary schistosomiasis co-infection assessed in the study had no significant difference (P>0.05). Gallagher and Hemphil (2004) and Franz and Horl (1999) had equally noted that in general terms urinary tract infection (UTI) is infection by Pathogen along the urinary tract causing inflammation depicted by pyuria indicating significant inflammatory response to bacteriuria such as occur with infection even in asymptomatic setting. These views mentioned above explicitly suggests that bacteriuria may be significant or non- significant depending on the quantity of bacteria in the urine which imply infection and is traditionally urine culture containing $\geq 10^5$ cfu/ml. The result of our assessment of bacteriuria in urinary schistosomiasis agreeably categorized 261 (90.3%) subjects by urine culture as having significant bacteriuria ($\geq 10^5$cfu/ml) with their sex distribution being significantly different (P<0.05) . This finding in consonance to that by Rushton (1997) which suggest that it may be possible to eliminate the urine culture when enhanced microscopic urinalysis and reagent strip urinalysis are negative and clinical suspicion is low. Nonetheless, isolation of significant number of single organism on culture remains the definitive diagnosis.

The finding of lower threshold of bacteria counts (10^2-10^4 cfu/ml) and the distribution of bacteria colony count according to different ova intensity which had a weak positive linear relationship (r = 0.2) deserves critical scrutiny because bacteria colony count and different ova intensity in urinary schistosomiasis was significantly different (P<0.05).This is pertinent to obtaining the best combination of sensitivity and specificity in the diagnosis of urinary tract infection. Franz and Horl (1999) reported that the utility and consistency of the criterion ≥105 cfu/ml of clean-catch urine for the diagnosis of UTI has been validated repeatedly. Thus, Stamm and Hooton (1993) noted that in dysuric patients, an appropriate threshold value for defining significant bacteriuria is 10^2cfu/ml of a known pathogen. Considering the foregoing and that dysuria is common in both early and late urinary schistosomiasis where ova count correlate with morbidity, it might be prudent to consider these thresholds significant for the diagnosis of UTI. More so, community –based epidemiological survey of bacterial count in Egypt (Mostafa *et al*., 1999) of subjects with *S. haematobium* infection had similar low bacteria counts (10^3 cfu/ml). However, interpretation of low threshold counts as significant for diagnosis must be in the absence of mixed bacteria growth with a predominant organism typical of contamination.

Infection of the 289 (80.3%) subjects with one bacteria or the other was the trend in our study and had no significant difference (P>0.05) in bacteria isolates between males and females. The isolation of *Esherichia coli* more frequently than the rest conforms to reports of many researchers (Farid, 1993; Mostafa *et al*., 1999) about it's association with schistosome infection.

The antimicrobial susceptibility pattern of the bacteria isolates to routinely tested first line antimicrobial agents were quite diminished. There were notable pockets of resistance to all first line agents tested except for Ciprofloxacin and Cefuroxime (Table 4). This antimicrobial susceptibility results would be an invaluable premise for empirical therapy where suspicion exists but cultures are impracticable whereas enhanced microscopic urinalysis and reagent strip are positive since comparative analysis of these methods had no significant difference (P>0.05). The main goal of most initiatives to control schistosomiasis is morbidity control. The reported complications of bacteria infections in urinary schistosomiasis are odious. Clinical and pathological conditions arising there from had been enunciated (Farid, 1993; Ganem *et al.,* 1998). Hence, this research further documents and authenticate the importance of a database for continued valuation and evolution of control programmes. The complementary incorporation of antibacterial therapy to the integrated morbidity control approach of diagnosis, drugs treatment, snail control, provision of safe, adequate water supply, sanitation and health education is

advocated. More over, our results infer that urinary schistosomiasis is endemic in FCT Abuja Nigeria and deserves urgent intervention.

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The Anatomy of a Volcano, Earth Quakes, and Tsunami
June 21, 2005

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Abstract: I'm an expert on earth quakes, tsunamis, and volcanoes. I have been working on earthquakes, tsunamis, and volcanoes for over 15 years. I have discovered how to control earthquakes that are caused by the ignition of methane gas reservoirs to the point of preventing them from occurring. There are two causes for Earthquakes one generated by the ignition of large pockets of methane gas, and the other is generated by volcanic activity. Both types of earth quakes are caused by the build up of excessive pressure in the upper mantle, and lower, upper crust. [New York Science Journal. 2009;2(1):29-31]. (ISSN: 1554-0200).

The first reasons for earth quakes are caused by volcanic activity, like the type that occurred in Mt. Fuji- Japan, Krakatau-Indonesia, Mauna Loa-Hawaii, etc. The earth quake that occurred during the Krakatau eruption in 1883 was, so powerful it generated strong earth quakes, which generated a tsunami, so large it killed tens of thousands of people. The pressure in the magma chamber was, so great it pushed a large area of the ocean floor upwards several yards above the surrounding area. The pressures in a volcano originate in the earth's outer core where crude oil, and it's components are combusted. The pressure in the outer core is distributed up through volcanic pathways to the volcano's magma chamber. Gases such as carbon dioxide, carbon monoxide, sulfur dioxide, hydrogen chloride gases, and high pressure, etc are all components of combusted crude oil. They are force up through the volcanic pathways to the volcano's magma chamber, where the pressure become so great it blow off the top of the mountain, where the carbon gases are ejected by the pressure. Earthquakes occur during volcanic activity, because the mountain top will not give way to the tremendous pressure easily. The pressure in the magma chamber, and volcanic pathways become, so excessive it pushes the surrounding lower, and upper crust apart, moving it laterally. Sometimes the pressure pushes the crust upwards, if this upward movement occurs in a large body of water a tide wave (tsunami) will form. Earth quakes generated by volcanoes can't be controlled. Volcanoes are the core's exhaust system. The core is the earth's engine it generate the earth's magnetic field, which protect, and sustains all life in the biosphere called earth. The higher the temperature in the core, the stronger, more violate, more wide spread, and more frequent volcanic eruptions will occur, and the stronger earth's magnetic field.The lower the temperature in the core, the weaker, less violate, less wide spread, and less frequent volcanic eruptions will occur, and weaker earth's magnetic field will become.

The second cause for earth quakes is the ignition of underground methane gas, and/or crude oil reservoirs, like the type that occurred South America, Mexico, California, Alaska, china, Russia, and Iran, and other countries in the Middle East, etc. All these places experience earthquakes in the past, and all these places have methane gas, and/or crude oil reserves beneath the ground in the area where the earth quakes occurred. These methane gas/ crude oil reservoirs are located all around the planet. There are areas on the planet that contain underground large pockets of methane gas/ crude oil reservoirs, and don't experience earthquakes. The methane gas in these areas are undisturbed methane gas reservoirs, but most earthquakes are cause by the ignition of large pockets of underground methane gases, not volcanoes.

The methane gas is ignited by coming in contact with magma, which has seeped up from the outer core, or the methane gas/ crude oil reservoir is being over pressurized. The methane gas come in contact with the magma the gas is ignited, then it expands, and push the lower, and upper crust apart, moving it the crust laterally, sometimes the crust is pushed upwards. This upward movement can occur on the sea floor,

or land. This is how faults, and tact tonic plates on the surface, and upper crust are formed. Faults, and tact tonic plates can't form on their own, and don't cause earth quakes. All hydrocarbon expands, when ignited, and nothing can withstand the pressure generated by ignited methane gas, not even an one inch thick carbon steel tank. What occurs in a methane gas earth quake is the same principal that powers the internal combustion engine. Fuel is sprayed into the engine cylinder, the sparkplug lights the fuel mixture, and the gas expands pushing the piston down. This is how the engine crank is turned. In methane gas earth quakes the expanding gas push the crust laterally, and sometimes large areas of the upper crust are pushed upwards. If this upward movement of the crust occurs in a large body of water a tide wave (tsunami) will form.

Reducing the pressures in the methane gas reservoir will weaken any future earth quake, or totally eliminate them all together. Caution, methane gas/ crude oil reservoirs are the earth's fuel systems. Some methane gas/ crude oil reservoirs can't be tampered with. The pressurized in methane gas/crude oil reservoir forces the crude oil into the outer core of the planet, where it combusted in gaseous form. This in turn sustains the high temperature in the core (the earth's engine). The higher the temperature in the core, the stronger the earth's magnetic field, which sustains all life in this bio-sphere called earth. The temperature in the core is determined by the amount of fuel (crude oil) it receives. Some of the pressurize methane gas is force back up into the crude oil reservoir to keep it pressurized. I believe the earthquake (tsunami) in the Indian Ocean that killed thousands of people a long the coast of Indian was causes by a methane gas earth quake, because the area is not known for volcanic activity.

I challenge anyone to prove my finding wrong! The other scientists have their theories, but I'm the only one that can prove his finding on earthquakes. All others findings are wrong, because tact tonic plates, and faults don't cause earth quakes, and they can't form on their own.

This is how to set off a man made earthquake (tsunami). Locate, and drill down into a large underground methane gas/ crude oil reservoir. There are large pockets of methane gas reservoirs all around this planet, including beneath the ocean floor, see figure #1. As in nature the ignition source must be large, hot and last as long as possible, so enough methane gas can be combusted, so enough pressure can be generated in the methane reservoir to move the lower, and upper crust. This is what happens when the methane gas come in contact with magma. These methane gas/ crude oil reservoirs extend for thousands of miles down to the outer core. Once the drill head is in the methane gas reservoir activate the ignition source, and ignite the methane gas.

Once the gas is ignited the explosion (blast) is silenced by the surrounding rocks, and soil, and can't be hear on the surface. The crust can't withstand the pressure generated by the expanding gases, and is pushed laterally, and/or upwards. There are small amount of air in a methane gas reservoir. That's why in nature the magma stays in contact with the methane gas for a long periods of time in order to ignite enough gas, which will generate enough pressure to move the lower, and upper crust, and create an earthquake.

The ignition source can be achieved by igniting the gas in the drill pipe, or the head of the drill pipe can be outfitted with a heat element, that generate temperatures well above the flash point of methane gas, as with figure #1.

The explosion take place hundreds of feet beneath the surface, and the explosion (blast) is silenced by the surrounding rock, and soil. That's why the blast from the ignited methane gas can't be heard by people on the surface. The blast, and epicenter are one in the same. It's the blast (epicenter) that cause the sock wave, and it the expanding gases that causes earthquakes. The shock wave from the explosion is picked up by earth quake sensors. The sensors pinpoint where the methane gas explosion (epicenter) took place.

It is possible to drill down in the area of the epicenter of the last earthquake in the Indian ocean, where the ocean floor was push up, and ignite the methane gas, and cause another earth quake, and tsunami

using the method in figure# 1. Since we know how the ocean floor will react to more pressure generated by the ignited methane gas. If a good ignition source can't be generated, it may be necessary to pump as much air into the methane gas reservoir as possible for 2-4 days with a high volume, high pressure pump, then activate your ignition source.

To prevent an earthquakes locate the gas in the area of the last earthquake, and drill down into the reservoir, and release the gas. The gas can be liquefied, and sold on the open market. Reducing the pressure within the reservoir will greatly decrease the possibility of another earthquake. My purpose is to convince you my findings on earth quakes, and global warming are correct, so I can show the world how to control, and/or stop these deadly events.

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为什么近代科学的萌芽未能发生在旧中国而是发生在文艺复兴后的欧洲?

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摘要: 古希腊文化与中国古代文化有很大差别. 双方几乎在同时起源于大约在公元前 500 年.像两条长长的河流, 两个文明流向不同的历史方向. 结果,由于文艺复兴后的欧洲文化继承和发展了古希腊的文化传统,于是, 欧洲现代科学技术随着时间的前进发展得愈来愈快, 终于给欧洲带来了工业革命和资本主义. 相反, 中国则保持中央皇权的封建制度和古老的文化传统直到 19 世纪末, 而现代科学萌芽还没有诞生. 在这篇文章中,将探讨不同的自然环境和不同的社会-政治经济制度对文化所起的举足轻重的影响, 因此,导致古人的不同的思维方式和行为方式, 使现代科学萌芽在旧中国和在欧洲终于产生了不同的结果,但这篇文章不是对两个古老的文化做全面的总结和分析. [New York Science Journal. 2009;2(1):32-46]. (ISSN: 1554-0200).

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注: 这篇文章是作者前篇英文文章"人类社会经济形态的改变和人类社会的发展的新观念"[15]的续篇, 该文现已翻译成中文发表。

关键词:中国古代文化; 古希腊文化; 现代科学的萌芽; 思维方式和行为方式.

引言: 爱因斯坦说:"西方现代科学的基础是建立在两个伟大成就之上的. 他们是:古希腊哲学家发明的形式逻辑体系, 和可能通过系统的实验而发现因果关系.据我所知, 中国的先贤并没有走那两步, 对此我并不会感到意外,应该惊奇的是不少科学发现仍然出现在旧中国. [1]" 最近杨振宁博士指 出:" <易经>在中国文化中影响了思维方式, 这种影响是现代科学萌芽没有出现在中国的一个重要原因. [2] "两个伟大的物理学大师、 诺贝尔奖获得者, 爱因斯坦和杨振宁博士几乎达到了共识,即中国先哲,知识分子缺乏正确的思维方式和行为方式, 他们过度地迷信上天、 君权、 提倡道德哲学造成了科学技术在旧中国的落后. 相反的,古希腊先贤从亚里士多德起,几乎都把大自然作为观察和研究对象. 此外,在文艺复兴运动后,欧洲学者摆脱了对神权的迷信; 而符合当时的社会需求的现代科学的萌芽就从航海和天体观察中产生了. 两位物理学大师的观点真是击中要害,因为现代科学是建立在严格理论和系统的实验相结合的基础之上的, 是建立在 理论上计算的数值与实验数据一致性的基础之上的,而且只有通过严格的逻辑思维和系统实验结果才可以提炼成的正确科学理论. 为什么古代的西方先贤和知识分子能用形式逻辑和实验发展科学技术,但中国古圣贤和知识分子就不能呢? 在两个古老文明中所产生的不同的思维方式和行为方式应该从他们极不相同的古代历史、 地理、 社会经济、 政治制度中去寻根问底.正是那些古代先贤的知识分子的不同的思维方式和行为方式最终导致现代科学的萌芽和发展在欧洲出现. 相反, 封建的旧中国直到 19 世纪后半期才刚刚开始从西方国家和日本引进现代科学技术.

1. 中国古老文化的起源:

中国古老文化大约起源于 2,500 年前的孔子。

(A). 孔子(551 -- 479 BC), [3] 作为中国文化的最了不起的代表, 出生在东周朝代。他的巨大的思想贡献表现在他所完成的<易经>和<论语>中. <论语>是由孔子的学生所记录的孔子的语录书。孔子的中心思想是"仁",它的主要内容是: "人人应该爱人如爱己, 正如天地爱人一样。己所不欲,勿施于人". “人人应该尊天命, 畏天命, 否则, 自作孽,不可活"。” 天地人是三位一体。天地生养人,人应敬畏天地”, 因此,所有的人, 从国王到官员到百姓只能敬畏和祭拜天地, 天地自然就不能成为被人们研究的对象. 孔子还教导: “人要畏天命,畏圣人之言" , “不怨天尤人, 不能怨恨上天对人的惩罚,一切都是咎由自取”.“ 百姓要服从君王 (天子), 官吏., 因为国王是上天的儿子, 官员是百姓的父母”。” 君王要为政以德, 官吏要忠君爱民, 百姓不能犯上作乱”.总之, 孔子"仁"为中心思想为给各种地位的人制定了思想和行为不可逾越的准则, 从而为维护封建制度和保持封建社会的稳定起了重大作用. 旧中国社会在 1949 年之前, 每个家庭的正厅中央墙壁上, 必有"天地君亲师" 的牌位供全家常年祭拜。结果, 所有人特别是古代的知识分子的思想和行为被对上天,君王和孔子的教条 **“三位一体”**的迷信所禁锢, 从而使现代科学萌芽所需要的逻辑思维和对自然界的探索无法成为旧中国的知识分子的追求对象.

(B). 约在孔子时代, 还有其它的伟大哲学家, 老子(大约 571 – 471BC), 他成了道教的始祖.[4] 他的思想也对中国文化产生了巨大的影响。他主张"清心寡欲" 和"与世无争" 。因而,如果某些人不满意现状,他们也许可以隐居住在深山老林而与世隔绝,终老一生。大概那时由于人口稀少有许多深山老林可供人们隐居以逃脱现实。另一方面, 他认为一位好的君王应 “无为而治”, “顺其自然”,他教导说: "无为而无不为".
大约在 孔子死后 100 多年, 他的追随者孟子(大约 372-289 BC)[5] 继承和发扬了孔子的思想, 孟子除了提倡"仁"之外, 还强调了"义" 的重要性.此外, 孟子特别反对"利" , “争利”和"为利而奋斗" 。"不争利" 和"寡欲"就使旧中国的学者对现代科学的萌芽缺乏探索的动力。

大约公元 200 年, 佛教 [6]开始在古老中国传播。在伦理上佛 (566 - 486 之间 BC) 与孔子的教导没有其他巨大区别。佛教导说: "勿作恶。栽善根。净化自己的灵魂". 佛教与孔子和道教最重要不同是宣扬"因果报应和轮廻转世", "死后灵魂能去天堂或地狱" 和"为来世而信佛" 。约在公元 230 – 630 年之间, 中国在南北朝时期, 大约有 400 年的连年不断的战争大灾难。人民的生活遭受长期而深重的痛苦。罪恶不能受到适当的惩罚。人们相信佛的保佑自己能有更好的来世从而提高个人生活的信心和增强克服困难的勇气.

所有上述教条之所以能广泛被传播, 因为它们符合当时社会和人的灵魂的需要.但是, 人的科学思维和行为无法从封建伦理和迷信中产生, 因为封建伦理和迷信是远离理性和逻辑思维.上述所有圣贤都共同地宣扬; "人人应该行善", "人人应该服从自然和上天的意志", "人人都应该清心寡欲" 。结果, 在 10 世纪后期宋朝建立后, 孔子 教条, 老子和佛教三者被结合在一起,成为儒释道的 **“三位一体”**, 之后就成为中国古老文化的主流,规范着全中国人的思想信仰和行为。

(C). 在孔子时代, 东周王朝已大大地衰落了, 诸侯们在天子的名义下实际上统治自己的领域和百姓..那时是一个社会的转型期,当时正值奴隶制解体而向新兴的封建制度转变,农业生产正逐渐变为主要产业, 各个诸侯国都有过剩的土地,而缺少人口,劳动力和谋士. 于是,各种学者和有技艺的平民可自由地出入各个诸侯国,而各诸侯国几乎是完全的独立王国,他们可以按自己的意志用自己的方式方法统治其臣民.那时还没有一个诸侯强大到足以灭亡东周王朝而统一中原, 各个诸侯国只是为争夺霸权而频繁发动战争. 那是中国历史上第一次经济繁荣而文化上百花齐放的时代.于是,各种学说学派蓬勃发展出来了. 那时,一个政治家或军事家为了实现自己的理想或成为诸侯的座上宾,可以周游许多国,向诸侯们兜售自己的政治或军事主张,以便得到某一诸侯的采纳作为而后治国安民的理念或方畧.

在孔子时代,大多数人都住在江河流域的大平原上,那里气候温暖雨量充分,较适宜于农业发展..除非发生了大的洪水或旱灾而又有诸侯的暴虐统治,老百姓均能过自给自足的生活.气候的四季变化并非难以预测. 因此, 生活在平原上的人们的风险比靠海洋生活的人们要小得多,因而人们也就会缺乏冒险精神.结果, 知识分子和学者也就无心探索自然和科学, 也无心为改善现有的生产条件和生活条件而奋斗, 而一心只想如何躲避未来的灾难.而老百姓的唯一愿望是顺从天意以行好运, 其次是幻想能有 “君君,臣臣,父父,子子”的和睦社会..因此,中国古代的圣贤们不探索自然而只想建立特自的伦理学以维持人们之间次序以便保持社会关系的和谐和稳定. 孔子思想的产生和广泛持久的转播是符合封建王朝政治需要和自给自足的小农经济的需要的,特别有利于在中国大陆维持一个统一的大封建王朝.结果是几千年来, 几乎所有的中国人都满足于封建王朝统治下的小农生产, 而对自然科学不屑一顾, 只有那些对封建统治者有利的技术才得到大力地发展. 比如, 用于战争所需的火药与刀箭, 用于官文所需的印刷和造纸,和用于治病伤的中医药等.

(D).自从秦始皇在公元前 221 年统一中国后, 2000 多年来, 大统一的封建王朝是符合农业生产的需要的,也较符合广大民众安居乐业的需要,因此大统一一直是人心所向. 加之,在广大的平原上各处都是易攻难守,难以形成像古代欧洲那样的长期城邦式的独立王国.因此,一旦统一破裂分为若干独立小王朝时,为统一而长期频繁的发动战争是必然的趋势,正如南北朝时一样, 老百姓只能过颠沛流离的痛苦生活.对老百姓来说,统一总比内战的日子好过些.这也正是老百姓宁可忍受元清外族王朝统治的原因.更重要的历来的封建王朝都是从战争中打出来的,甚至在其家族内部也不可能实行民主,因为民主必然导致内战. 两千多年的专制统治导致中国没有产生真正意义上法典,法律,契约,诉讼争辩,面对面的平等争论等民主所需要的东西.因而就不需要精确的语言和严格的逻辑思维.这就使得古代中国圣贤和知识分子缺乏探索自然科学的思维能力.

(E).然而,帝王和官吏很难得不作坏事,而这关系到每个人未来的命运,这对官吏和读书人尤其重要. 这也就是孔子的 <易经>两千多年来在中国流行的原因.因为每个人特别是官吏和读书人总想从<易经>的扑卦中预知自己未来的命运以谋避凶趋吉.什么是<易经>的思维方式呢? 它用比喻的方法取代具体的分析,用形象化取代逻辑思

维, 模棱两可的类比和影射取代定量分析, 用归纳法取代演绎法,用空谈取代明确的语言,用虚构的天地物的行为比喻人的行为等等.<易经>学家总是用模棱两可的影射给别人算命,並常显示自己高深莫测的学问以谋私利.

中国语言和思维的不精确性在<易经>中充分反映出来了,它妨碍了古代中国学者作精确的科学分析和逻辑思维. <易经>中的每一个卦都是用天象和地象去比喻人的命运.结果许多古代中国的聪明学者终生都沉醉于<易经>的神秘玄学, 他们不去研究天地的具体的规律与人类社会和各种事物规律之间的差异, 最后, 他们甚至将天上的每颗星星与地上的每个人的命运相对比. 古代中国文化主要来源于<易经>和孔子老子的思想,这成为旧中国农业社会中大多数人的共识,也成为维持封建王朝的帝王和官吏的需要.

(F). 在旧中国,每一个知识分子除了读圣贤书,旧文学和政治历史文献外,就无所作为,因为只有学好这类书才能通过封建的科举考试而做官,即 “学而优则仕”. 旧知识分子们不屑于参加各类生产劳动,他们 “四体不勤,五谷不分”,对物理世界的观测和试验毫无兴趣, 好的知识分子一生中唯一的 “兴趣” “欲望” 和 “理想”就是力行孔子的教导 “修身,齐家,治国,平天下”,而坏知识分子就是 “贪官污吏,鱼肉百姓”.

(G). 在旧中国, 老师对学生的教育不是用启发式的对话式的平等的教学法,而是用训斥甚至体罚的方式老师对学生的关系是 “一日为师,终生为父”,而学生只有 “尊师重道”,即要谨守孔孟之道,因此,学生极难产生科学所需的批判和创造精神.

(H).自给自足的小农经济长期的年复一年的有条不紊的循环养成了人们靠天吃饭的循规蹈矩的思想和行为.几千年来整个旧社会都重农业,轻工商, 因而人们缺少追求财富,科学和真理的欲望.加之,整个中国大陆周边都是贫穷落后的民族地区和国家,没有财富可供掠夺,甚至封建统治者也缺乏对外掠夺的欲望.

(I).文字是思想的工具和载体.古中文是象形文字而且有多种意义, 文法不严格而往往缺乏谓语,一个字可用之于多词类,一句话的准确含意往往只有对照前后文才能确定,因而较适宜于形象思维和类比,[7]较难用于逻辑思维和严格的概念和论证. 这也是旧知识分子难于运用逻辑思维的原因之一. 例如,人人皆知的中国格言 “江山易改, 本性难移”,其实, 江山和人的本性之间並无必然的因果关系,而江山一词本身也是多义的.这类类比在中国古文中俯拾即是,而又往往成为完美的佳作被人赞颂.

如上面所分析, 旧中国文化中缺乏近代科学萌芽所必需的许多条件,例如, 旧中国从皇帝官员文人到老百姓都不把自然界当作研究和实验的对象,而是 “听天由命”, “畏天命,畏圣人之言”.封建的科举制度使旧知识分子把做官作为自己终生的奋斗目标,而他们所读的书籍全部都是缺乏逻辑思维的古典文学和政治历史文献.因此, 古人的思维能力和行为方式就是如何用卜卦和各种迷信对自然灾害 “避凶趋吉”.

总而言之, 在旧中国, 一个建立在全大陆的大统一的中央集权的封建王朝, 一个建立在全大陆的自给自足小农经济,一个统一的象形文字和儒释道文化,这种经济政治文

化三者所结合成的**“三位一体”**是中国社会几千年来成为一种难以进步的“超稳定结构”.在这种结构里,由于中央王朝的重农抑商和垄断资源，就无法形成为利益而竞争的自由市场，也就没有可能发生近代科学的萌芽.

然而,当中国近代知识分子认识到的古代中国文化的缺点后,他们是能够毫无困难的运用逻辑思维和做系统的实验为近代科学作出贡献的.而中国的传统文化在清除封建糟粕和吸收西方近代科学技术之后会成为更加灿烂的中国新文化,因为中国文化具有非常大的包容性和吸收能力.例如,中国现代语言和结构已经西化,而许多中国现代知识分子在学习西方的科学技术后已在科技上也取得了巨大的成就.

2. 古希腊文化的根源:

西方文化发源与约公元前 500 年的古希腊文化.

苏格拉底 Socrates (469--399 BC.), 柏拉图 Plato (427--347 BC.)和亚里士多德 Aristotle (384--322 BC.)被誉为古希腊三圣,他们是古希腊文化的伟大代表,而亚里士多德是古希腊文化的思想和学问的集大成者,他们三位都宣扬科学的思维方式所需要的理性. 欧洲人继承了古希腊文化的优良传统导致了近代科学在文艺复兴后在欧洲的萌芽和发展.那么, 古希腊文化是如何从当时古希腊的特定的社会政治经济和历史地理等等的条件下产生的呢?

(A). 苏格拉底. Socrates[8] 生于公元前 469 BC,（即孔子死后 10 年,). 苏格拉底时代是雅典帝国的黄金时代,特别是伯里克利作为雅典帝国 10 人执政委员会的首席执政官的 15 年(443--429 BC),这时候是雅典帝国的奴隶制民主达到了灿烂的顶峰.在伯里克利时代,雅典帝国统治着超过 200 个附属国,1000 多万人口,建立了约有上千船舰的庞大舰队,爱琴海变成了雅典帝国的内海, 雅典成了当时最大的港口.

在地理上, 希腊是一个小的半岛,三面环海,背后是山脉.半岛上多为山丘,而缺少大平原和大草原. 因此,农业和畜牧业在雅典帝国难有大规模的发展.大部分人只能从事海上贸易和从海外城邦掠夺财富.然而,海洋气候常常迅猛变化莫测而造成海上波涛汹涌.因此,生活在海洋上人们逐渐养成了冒险精神,征服自然的精神和对自然做斗争的精神,他们养成了踏实工作和作周密的试验的习性,他们有从海外赚钱和掠夺财富的强烈欲望.所有上述溶合在古希腊文化中的精神财富都被西方文化所继承而有利于近代科学萌芽在欧洲出现.

长期生活和奋斗在海洋上的民众逐级建立和发展出了一种 “海洋文化”.其主要内容就是:冒险精神—人们相信自己的判断能力和力量而不是 “靠天吃饭” 和 “畏天命”, 科学态度—注重试验以获实效,不空谈,手脑並用,仔细的计算和準确的数据, 强烈的掠夺和征服的欲望—信奉丛林规则,崇尚武力,为满足掠夺和征服的欲望而不顾艰险地奋斗..

(B). 伯里克利 Pericles (495 – 429 BC)[9] 出身于贵族家庭,他有大量的田产和商业产业. 他有广泛的学问和才能.在奴隶主中,他是心胸开阔的民主主义者.他把奴隶制民主提升到最高峰.他认为: “人本主义—人民(不包括奴隶)是第一重要的”, “人民只有有了

自由才有幸福", "平等,自由,法制是民主的基本原则".在伯里克利的领导下, 雅典成为雅典帝国中经济发达,政治稳定,文化繁荣的中心城市.[9]当然, 雅典帝国的繁荣强大是建立在剥削,压迫,奴役和屠杀附属国以及奴隶的基础上的. 但是, 伯里克利所坚持实施的完全民主和平等权利只限于雅典城中的年龄 20 以上的男性公民(贵族和平民),而不包括女性,奴隶和非本地人. 雅典帝国权力的最高机关是雅典的公民大会和公共法庭.

公民大会选出 10 个执行官的委员会成为雅典帝国的最高权力执行机关. 10 个执行官的候选人必须作许多的演讲和参加许多的辩论会以宣传自己的政治纲领. 伯里克利是一个最好的演说家. 公民大会每 10 天举行一次,以决定重大的内政和外交问题:战争或者和平,惩罚或是罢免执行官或选出新执行官等.

公共法庭是雅典帝国的最高审判权力机关.在伯里克利时期, 公共法庭的作用被大大地加强了. 雅典的法官增加到约 6000 人.所有附属国之间的诉讼, 附属国与雅典之间的诉讼都由雅典的公共法庭审判.公共法庭还要管理所有的重大的民事和刑事案件.因此,那时整个雅典几乎成为一个到处都是政治和各种各样的演讲和辩论的巨大的会议厅.在所有的演讲和辩论的场所, 演讲和辩论者都需要会运用精确的语言文字,古希腊人特别善于在法庭上运用数学和数据分析,他们不满足于经验的证据.他们要求所提供的证据具有普遍的确定性,也就是说,要求所提供的有关政治的哲学的和法律的论证是可靠的,这种可靠性只能用数学和数据的确定性表示出来. 所有上述雅典帝国的政治社会和历史条件为发展数学和逻辑学创造了良好的环境,以导致古希腊学者的思想和行为特别注重数学,科学和逻辑学,而这些后来逐渐成为古希腊文化和哲学的重要内容.

(C). 形式逻辑产生在具有完善的奴隶制民主的古希腊不是偶然的.为什么那种民主会出现在古希腊而不出现在古中国呢? 这是古代二者不同的历史社会和地理等条件所造成的. 古希腊在雅典帝国时期是由许许多多小的和相对独立的城邦组成的. 希腊本土是一个不大的半岛,多山和丘陵,而没有大的像中国一样平原.因此,很难建立成一个长期的统一的像中国一样的大帝国,而只能依丘陵的山势和海中的岛屿等地理优势来建立小的能自保的独立的城邦. 各城邦为了自卫而不致被其它城邦掠夺或被打败而沦为奴隶,就需要贵族和平民一起当兵以集体自卫,同时也是为了能集体去打败和掠夺别的城邦.因为奴隶不能当兵,这样一来, 贵族和平民之间因集体自卫和集体掠夺的共同利益和命运而逐渐形成为奴隶制民主,而这种民主也有利于镇压奴隶的暴动.在城邦之间谁也不能打败谁的情况下,就要发展平等的贸易或联合起来对抗强大的共同敌人,这也需要民主.民主给古希腊雅典帝国和各小城邦带来了宪法法律诉讼法庭竞选辩论等,所有这些都需要严格的思维和精确的语言.民主也有利破除迷信和发现真理.这就是形式逻辑和逻辑思维在古希腊产生的条件和土壤.

古希腊人从与腓尼基人[7]的贸易中学会了字母最后形成了古希腊语言.这种语言是有利于逻辑思维的. 因此,形式逻辑在古希腊诞生是有社会历史基础的.

(D). 在伯里克利执政的 15 年期间,正是苏格拉底 26 ~ 40 岁的年龄. 苏格拉底用启发式和辩论式的方法教育他的学生.他本身就是当时的一位辩论大师.他是雅典帝国黄金时代的时势造就出来的,是当时社会需要的产物. 苏格拉底创造了道德哲学,他特别提倡伦理学.他特别强调: “理性导向道德”, “善来源于学识,而恶来源于无知”. 苏格拉底的上述的思想和观念大概是当时社会实际情况的反映.他生活在繁荣昌盛,民主和法治的伯里克利执政时代,眼见为实的某些官员,特别是像伯里克利都充满着善,理性,智慧和广泛的学识,而使苏格拉底突出地看到了人性中善的一面, 从此建立了他的伦理学.他还提倡归纳法,告诉人们如何从许多具体的事例中得出正确的判断. 然而最后,苏格拉底却由于宣扬出自于他的理性的新 “神”而被判处死刑.

(E). 柏拉图[10]是苏格拉底的学生, 生于公元前 427 BC 年,比苏格拉底小 42 岁. 伯里克利在公元前 429 BC 年死后, 雅典帝国极大的腐败和衰落了,最终在公元前 405 年被斯巴达所取代. 在柏拉图的生活中,他经历的是雅典帝国极大的腐败衰落和斯巴达的统治.在柏拉图的眼里,真实的世界是非常腐败和丑恶的,他对当时的政治,法典和常规特别地厌恶. 苏格拉底在公元前 399 年为自己的信仰而被处死给柏拉图非常强烈的刺激. 柏拉图把苏格拉底看成是理想和智慧的真正化身,却终于被民主暴力所处死. 由于对雅典帝国末期民主暴政和斯巴达混合统治制度 (皇帝加贵族加监督官的统治)的失望, 柏拉图认为感性的识识和世界是纯粹的幻觉,而只有理性的认识和世界才是真实的和可靠的. 柏拉图里决定将其老师苏格拉底的哲学思想加以发挥,把苏格拉底关于理性和善的观念推广到最高的境界而成为 “真,善,美”. 他最后探究在世上建立理想国的理论. 一方面, 柏拉图认为理性的和善的政治家在未来的任何制度中是必然需要的, 而善只来源于理性, 理性从知识中产生. 于是, 柏拉图在雅典创立学院招收学生学习哲学和数学. 他实行毕索哥拉斯 Pythagoras 的观点; “任何事物皆是数”. 在他的心中, 数学和几何是最理性的,所以是最可靠的,因而可以精确的应用到商业,航海,天文和建筑等等中.因此,只有掌握数学和几何的理性的人才有智慧,才能导致理性的行为和善,也只有这种人才能成为好的执政者. 在柏拉图学院的大门前,门牌上写着: “不懂几何者不得入内”. 当时许多的政治家和数学家曾在柏拉图学院学习过. 另一方面, 柏拉图把斯巴达的军事共产主义的某些社会制度当作他的理性国的翳型.上述两方面的结合就成了柏拉图的 “乌托邦” 的主要内容.

(F). 亚里士多德 Aristotle,[11] 生于公元前 384 BC 年,是柏拉图的学生之一,他从 17 ~ 38 岁在柏拉图学院学习了 20 年. 稍后, 亚里士多德成为亚历山大三世 Alexander III 大帝的老师. 亚历山大大帝是马其顿的伟大皇帝,在他 13 年的讨伐战争中,他创立了一个包括部分欧亚非三个大陆的庞大帝国. 公元前 338 年, 亚历山大大帝的父亲菲力普二世 Philip II 统一了希腊各城邦. 雅典成为亚历山大帝国的附属国而得到了短暂的和平和繁荣. 亚里士多德从公元前 338 年直到他在公元前 323 年亚历山大逝世的 15 年内在雅典创立了学院,並在学院内从事科学研究和著书立说.他的学院从亚历山大大帝那里得到了大量的金钱捐助. 亚里士多德在公元前 322 年逝世,即亚历山大大帝死后 1 年去世.

亚里士多德在他创立的的雅典学院的光辉灿烂的 15 年生活期间,正是亚历山大大帝统治着雅典. 亚里士多德作为教授教书的同时,大量的著书立说,他完成了<物理学>,<

天论>,<伦理学>,<形而上学>,<政治学>,<工具论>等流传下来的 30 多种巨著.他的著作不仅集中体现了灿烂的古希腊文化,而且使其发扬光大到顶峰,它是欧洲文化和科学产生和发展的根源. 亚里士多德的著作是批判的,平淡的和细致的,而非热情洋溢.他不是充满激情的先知. 亚里士多德批判了许多柏拉图的观念,比如,理性主义,乌托邦等.他说: “吾爱吾师, 但吾更爱真理”. 柏拉图坚信: “理念是物质客体的原始模型,它的存在是不倚赖物质客体的, 感觉不可能成为真正知识的来源”. 然而, 亚里士多德喜好独立地观察和思考,他认为: “知识来源于感觉. 物质客体本身已经包含了它自己的本质,” 亚里士多德在其认识论中将物质客体,实在,世界和事物的存在放在第一位和最重要的地位.他极其重视观察和研究自然现象和自然规律,他卓有成效地研究了天文,气象,动物,鸟类等等.他在其著作著中表达了他的观念: “宇宙,人类生活以及社会的各个方面统统都是分析和思考的对象.宇宙中的各个事物不是被神,运气或魔术所控制,而是按照某些确定的规律运动.因此,自然界是值得人们系统地研究的,人们应通过实验和逻辑分析而得出结果.” 亚里士多德的反传统,反神秘主义和反迷信的主张对以后的西方文化产生了重大的影响.

亚里士多德的主要政治观点有: “好的政府有三种:君主制度优于贵族统治,而贵族统治又优于共和制.然而,一旦最好的制度腐化堕落,它就成为最坏的了”.在他的眼中,“富人的寡头统治和平民大众的民主(专政)都是坏政府”.他的著名的论点是: “民主是政治家的敌人”. 亚里士多德坚信 “中庸之道”.在他看来, 斯巴达和雅典帝国是两个极端.显然,他的政治观点深受他的经历和当时政治现实的影响.他清楚地认识到雅典帝国和斯巴达消亡以及苏格拉底被处死的意义.他经历了斯巴达的混乱统治,经历了不可预见的庞大的菲力普--亚历山大帝国在 15 年内的迅速建立和迅速崩溃.这些历史的巨变使亚里士多德确信一个强大而不腐败君主政体才是大大优于雅典的民主制和斯巴达的混乱的共和制的.

亚里士多德力图将存在与思维模式统一起来.他在<工具论>中,着重阐述了演绎法.因此,他成为形式逻辑的奠基者.为了保证思维的可靠性. 亚里士多德将思维的规则规范化,那些规则就称之为“逻辑”. 他还首创用形式逻辑研究了几何学.

事实上, 亚里士多德几乎创导了正确的 “认识论”或者说在科学研究中的 “方法论”,即对客体的正确的观念和结论只有建立在系统实验的基础上和通过逻辑分析才能得到.在以后一千多年的长期历史中,他的上述观念只不过是未被大多数学者所公认的一种假说,因为稳定的自给自足的小农经济的长期存在和充满迷信,那时的知识分子无需也无法认识到将自然介当作实验的对象.特别是 “中世纪”,在罗马天主教和使徒信经的统治下,几乎所有亚里士多德的错误观点都成为维护罗马神权统治的教条,比如, “天体是神圣的天神”就是他的错误观点之一.这就是为什么近代科学萌芽只能在文艺复兴后的欧洲产生.

(G) 欧几里德 Euclid,[14] 出生于公元前 330 BC 年,即亚里士多德逝世前 8 年,他是古希腊最伟大的数学家.他在其著作中成功地将亚里士多德的逻辑学运用于几何学;他从 5 条公理和 5 条公设出发通过演绎法井井有条地证明了 467 条最重要数学定理.

这是人类历史上首次成功地运用演绎法于科学思维从而导致演绎法成为建立科学理论的规范.而且, 欧几里德还发现了光的反射定律和浮力原理.

3.比较,分析和结论

(A). 根据前面的陈述可知, 系统的实验和运用形式逻辑仅仅是科学研究成功的必要条件,特别是近代科学萌芽产生的必要条件.然而,学者们能自觉地掌握运用形式逻辑和系统的实验去从事科学研究还需要经历一个长期的历史过程.也就是说,成熟的社会政治经济条件是近代科学萌芽产生的充分条件. 在欧洲,只有当中世纪的对罗马天主教神权的迷信在文艺复兴后被破除了,而且当航海天文和其它技术的发展能给当时的科学家和社会带来财富时, 近代科学萌芽才能发生和发展壮大以满足社会经济的需要. 这就是为什么虽然亚里士多德早在公元前 320 年就清楚地指明了科学研究的正确途径,而近代科学萌芽却只能在 2000 年后,在 16 世纪文艺复兴后的欧洲发生的原因. 反观古代中国,在 600 多年前的明朝,即在哥伦比亚 Columbus 出生前,太监郑和 [12] 率领庞大的舰队 7 次到南海诸岛和印度洋,他的舰队约由 300 艘舰艇和 30000 人组成,其航海技术和规模在当时无疑是世界第一的.然而,由于郑和的舰队並不是为了寻找或掠夺财富,人们仍然迷信封建王朝的皇权和孔孟之道,因而,此后 500 年来,近代科学萌芽仍不能在旧中国出现,因为直到 1840 年鸦片战争前,**旧中国的大统一封建王朝,自给自足靠天吃饭的小农经济和统一的文字文化的 "三位一体"所形成的超稳定结构一直没有被打破**.

(B). 近代科学萌芽的产生需要适当的气候和土壤. 文艺复兴就是适当的气候,而那时欧洲各国和城邦之间的繁荣的海上贸易就是土壤.望远镜的发明和使用可作为近代科学萌芽产生的标志.

中世纪亦称之为 "黑暗世纪",约从公元 400 ~ 1500 年,那时, 罗马天主教和基督信条非常严厉地统治着人们,它宣扬禁欲主义和经院哲学. 罗马天主教堂建立了宗教裁判以严厉地惩罚异教徒和严格地控制科学思想的传播,甚至于几乎将所有亚里士多德的错误观点当作维护罗马天主教的教条. 基督教的核心信条是人类中心主义,它宣称地球是宇宙的中心,而人是地球和万物的中心. 因此,只有上帝能统治人类,而人类应当按照上帝的旨意在地球上统治万物,同时,上帝也付给每个人平等权利和自由.如此,在中世纪的欧洲, 近代科学是无法产生的.

早在文艺复兴 Renaissance[13] 前,马可孛罗 Marco Polo 从陆地到中国旅游 20 年后,于 1298 年回到了意大利.之后,欧洲知道了在世界上,有许多美丽而富裕的东方国家.在文艺复兴时期和之前, 意大利有许多自由贸易的港口城市,那里的经济和手工业都很发达.他们都仰慕东方国家的财富和繁荣.

早在文艺复兴前,在中世纪的欧洲,一些国家已经建立了以古代柏拉图学院为前辈的许多大学,这些大学教授数学和科学.公元 1150 年,创建了巴黎大学,1168 年,正式建立了牛津大学[14].

文艺复兴发生在 15 世纪的意大利,它宣扬人本主义和破除中世纪对罗马天主教神权的迷信. 文艺复兴给欧洲带来了宗教改革.新的基督教改革宣扬平等,自由和博爱,提

倡恢复原来的基督教导和早期朝气蓬勃的教堂生活,反对现有的罗马天主教教条.宗教改革完全符人本主义和古希腊文化的传统精神.结果, 宗教改革又反过来帮助了文艺复兴的发展.

一方面, 文艺复兴反对禁欲主义,而提倡享乐主义.因而文艺复兴所赞颂的个人自由和个人英雄主义与改革后新基督教的教规相符合.因此, 大大地激发了个人寻找财富的欲望.哥伦布 Columbus (1451 – 1506 AD)在坚信地球如园球的信念下,他要远洋航海到西印度群岛去寻找财富和黄金,但是他却意外地在 1492 年发现了美洲大陆.

另一方面, 文艺复兴恢复和发扬了古希腊和罗马文化的优秀传统,特别是民主和科学的传统精神. 文艺复兴的优秀代表们特别重视亲自参加各种实验. 列昂纳多•达•芬奇 Leonardo da Vinci (1452 – 1519AD)说过: “真正的科学起始于观测”, “如果科学不是从实验中产生, 不是从准确无误的实验中产生,它就是毫无用处的,而将充满错误,因为只有实验才是真实的母亲.” 达•芬奇言行一致, 他反对流行的亚里士多德的观点, 认定: “天体正如一部机器,它遵守自然界的某种确定规律.” 在 1490 年, 达•芬奇研究了水在毛细管中的运动.[14] 文艺复兴的杰出人物们对欧几里德和阿基米德的尊敬更甚于对亚里士多德的尊敬. 在亚里士多德之后, 科学家们放弃了企图对自然界完整体系的探索,並转向对具体问题的研究.这正是亚里士多德的正确的研究方式对后世科学家们的重要影响.

地球是世界中心的教条是中世纪维系罗马天主教神权的主要支柱. 伽里略 Galileo (1564 – 1642AD)[14] 是长期的哥白尼 Copernicus' [14](1473 - 1543)理论的信徒. 哥白尼认定地球是在围绕太阳运动. 从 1610 年 1 月 10 日起, 伽里略为了验证哥白尼理论的正确性,用自己制造的望远镜对准天空中的月亮,金星,太阳和土星等进行观察. 在观察了月亮之后,他感叹道: “原来, 月亮和地球是一样的.” 从此以后,神权的迷信就被彻底地破除了. 于是, 近代科学萌芽就在 1610 年 1 月 10 日在欧洲从伽里略的望远镜中产生了.人类应该永远记住这个伟大的日子.**人类从此以后认识到整个自然界中的天地人有统一的物质结构。**

大约在欧几里德之后 2000 年,在 1687 年, 牛顿 Isaac Newton (1642 - 1727)[14]完全照搬公元前 300 年欧几里德在其几何原本中所运用的演绎法,应用到自己伟大著作<自然哲学之数学原理>中,取得了辉煌的成就. 牛顿的成就用他自己的话说是 “站在许多科学巨人的肩上”取得的. 牛顿的另一伟大成就是严格地按照演绎法推导和发明了微积分,他还发现了以他的名字命名的万有引力定律和物体的运动三定律.**他首次让人们得知, 自然界任何物体的运动, 不管是天上的还是地上的, 都不是毫无规则的, 而是都必须服从统一的确定的规律, 而这些规律是可用精确的数学公式来描述和计算的.**他所发现的那些定律是近代科学的大树上永不凋谢的花朵和果实. “通过与实验的比较来检验和改进理论的现代科学研究方法实际上也是他创立的.”[14]

克卜勒 Kepler (1571 - 1630)[14]通过许多年的系统的观察计算和推导发现了行星运动的三大规律.他的伟大成果为牛顿发现万有引力定律奠定了结实的基础.

在 1784 年,瓦特 James Watt (1736 - 1819)[14] 利用炮筒作为气缸发明制造了完善的蒸气机.这是人类现代科学技术上最伟大的成就.从此以后,人类就可利用自然界的无穷力量为自己服务.人类就可全靠自己的智慧而不是单靠自己的体力劳动为自己谋幸福.

文艺复兴首次为欧洲带来了文学艺术革命,然后带来了,从而使欧洲最终走向科技革命和资本主义.因此, 文艺复兴就成为欧洲近代科学萌芽的最佳气候,而欧洲当时的许多独立国家和相对独立的城邦和港口城市之间的繁荣的海上贸易是近代科学萌芽的最佳土壤.

(C). 为什么古代希腊人和以后的欧洲人喜欢对自然和事物进行观测和实验而古代中国人就没有这种喜好呢? 如上所述,古代二者长期的大不相同的生活环境造成了他们不同的生活方式, 思维方式和行为方式.生活在海上和海边的古希腊人认识到个人命运的改变和凶险正如海上的气候一样是难以预测的,他们只得靠自己对大自然和事物的观测实验以避凶趋吉.而古代中国人生活在大陆平原上靠天吃饭,他们的生活作息都是日复一日年复一年的循环有序的进行,生活是相对稳定的.隔几年偶有洪水或旱灾,也认为是"上天"对 "子民"罪过的惩罚,于是从皇帝官员到老百姓都跪下向"上天"祈祷. 孔子教导说: "获罪于天.无所祷也." 这就是说,在中国古人和圣贤的心里,只要不做坏事得罪老天爷,就能过风调雨顺的平安日子.因此, 中国古人和圣贤既不敢也懒得对自然界和事物进行观测和实验了.

(D).一个民族或国家的人们的思维方式和行为方式主要为其文化所决定,而文化主要为其生活方式所决定,而生活方式又为其社会政治经济制度和自然环境所决定.因此, 归根结底, 人们的思维方式和行为方式是为其社会政治经济制度和自然环境所决定的,也会随着社会政治经济制度的改变而改变.反之, 人们的思维方式和行为方式的改变也会促进或阻滞其社会政治经济的发展.在古代,由于科学技术发展很慢,导致生产力停滞不前,而社会政治经济往往循环往复而无发展, 因此, 自然环境对当地人们的思维方式和行为方式的影响是很大的.但到现代,由于科学技术发展很快, 社会政治经济也跟随着快速发展以至于改变了人们的生活方式,最后也改变了人们的思维方式和行为方式,而自然环境对人们的思维方式和行为方式的影响力也就越来越小了.这就是说, 人们的思维方式和行为方式并不是先天固有的,而是能够改变的,是一定的社会生活环境的产物,只是在其传统的影响下改变得早晚快慢的不同而已.

因此, 人们的逻辑思维和作实验的能力并不是某特定民族的天赋,是一定的生活环境和生活方式作用下形成的,是不难学习到的.现在许多发展中国家正在走向工业化和现代化,就足以证明那些国家的知识分子能够运用逻辑思维和作实验的能力以掌握和发展近代科学技术.再看许多中国的学者年青时虽然受了中国的传统教育,但以后到美国学习和工作后,在科学技术上取得了巨大的成就,一些中国学者还获到了诺贝尔奖.

然而,在严重的危机或极大的诱惑面前或生死关头,人们的个人欲望或情感会强迫自己迅速地改变思维方式和行为方式. 一个集团或一个国家民族也有类似的情况.这就

是促使一个国家发生改革进步或革命的原因,也是导致个人或集团犯罪或者转危为安的原因.

(E),在中国古代,在大陆平原上的中国人是长期的过着自给自足的小农生活,是靠天地的恩赐生活,这就是孔子<易经>老子和佛教的思想能站主导地位的原因. 一个由自给自足小农经济, 大统一的封建王朝,和统一的象形文字和上述保守的儒释道文化所组成的这种经济政治文化三者所结合成的**"三位一体".**两千多年来这种"超稳定结构"阻碍了社会的进步和发展,也禁锢了知识分子的思想和行为. 从而使近代科学萌芽无法在中国发生. 因此,如果没有外力的强烈冲击, 中国人的旧思想习惯是很难逃出那儒释道**"三位一体"**的控制的, 旧知识分子也就只有墨守成规, "学而优则仕",而不可能从事科学观测和逻辑思维. 在 1840 年鸦片战争以后, 旧中国由于科学技术落后而遭受西方列强的侵略和掠夺. 到 20 世纪初,中国的本土又被一次又一次的瓜分. 在这国家命运的生死存亡的关口, 中国知识分子在 1919 年的五四运动中提出了学习西方民主和科学,并提出了打倒孔家店的口号. 此时, 旧中国的**"三位一体" 在 1911 年的辛亥革命推翻了封建王朝和五四运动后已经被打破了两位,而只剩下小农经济了**. 相反,古希腊文化源于古希腊的完善的奴隶制民主和海洋贸易,这种民主导致古希腊知识分子产生了逻辑思维,平等讨论和争论的精神,服从真理和事实的精神. 而海洋贸易使希腊人产生了冒险精神,实验的习惯,赚钱和掠夺财富的欲望.所有这些思想精神传统都被文艺复兴所继承和发扬了.

(F)简要地总结以下,不同的古代文化对近代科学萌芽的影响主要地取决于古代知识分子和人们的不同的思维方式和行为方式.**古希腊哲学基本上是自然哲学**,因而古希腊先哲所创造的形式逻辑和演绎法是他们对自然界和社会进行观测比较的结果.在古希腊的雅典,经历过奴隶制的民主,共和制和君主制,既统治过别人,也被统治过.因此,形式逻辑和演绎法是从仔细的观测,详尽的比较和有理有据的辩论中发展总结出来的.**而古代中国的哲学基本上是一种道德哲学,或伦理哲学,** 是一种教各种人安分守己的行为哲学,它教人要如何各安其位,各行其事,而 "不逾矩". 每个人都要 "畏天命", "畏圣人之言",和不能 "犯上作乱".所有这些都被以后的封建统治者利用以维护其统治,保持社会的稳定.而古代中国从 4000 年前的夏朝起就一直实行帝制,因为在大陆的大平原上不可能存在象古希腊那种能独立自卫自保的城邦,因此,皇帝之被尊为 "天子"已成为古代中国圣贤和老百姓思想中不可动摇的信仰.这就是说,古代中国没有产生近代科学萌芽的思想基础. 那么,这是不是就表明古代西方的文化传统和哲学在各个方面都优于古代中国的文化传统和哲学呢? 当然不是,每种文化传统和哲学都是博大精深的,各有其优势和劣势和其存在的价值,都是长期地特定的社会政治经济制度和自然环境的产物,并都经过几千年的历史考验未被淘汰反而都仍在发展.这就表明,在现代,**各大文化之间的冲击不是谁战胜谁的问题,而是相互取长补短相互促进和溶合问题**.但也都要与时俱进,不能抱残守掘.

(G). 西方文化来源于古希腊文化,该文化传统的是奴隶制的民主和海上贸易的冒险精神和求实精神.**但古希腊的奴隶制民主只是狼与狼之间的民主,**即只承认奴隶主之间的民主,而不承认狼与羊之间的民主,即奴隶主与奴隶之间的民主,这就形成了西方文化中的主要内容和特点是: 一方面是,个人主义,个人英雄主义,个人自由主义, 强烈

的个人竞争欲望,追寻和掠夺财富的欲望,冒险精神等.按照基督教导,人人都有原罪,这样一来,人类的本性与动物就没有本质的区别,因此,弱肉强食的丛林则,社会达尔文主义和种族主义也深入许多人的心中..另一方面是,科学和求实精神,民主,平等,自由和博爱等精神.特别是经过文艺复兴和宗教改革后以及数百年来科技和社会经济的进步,资本主义的发展,再加上广大中下层民众不懈的争取平等的斗争,上述许多好的精神和传统得到了发扬,而某些坏的精神和传统得到了抑制,从而使西方发达国家实现了现代较全面的民主制度.在现代西方社会,人与人之间的关系主要是横向的金钱关系,而其它的所有关系都是次要的,而且可以说是完全平等的. 个人欲望的恶性膨胀是社会中个人犯罪的根源, 已成为西方社会的毒瘤.而西方发达国家的执政者和垄断资本家的个人欲望的恶性膨胀就成为霸权主义和国际间战争的主要原因.这似乎是继承了古希腊奴隶制的民主对外掠夺的劣根性.

相反,古代中国文化将"天" "地" "人"当作 "三位一体", 三者都产生于 "道",即自然,三者应和谐共处. 但 "人"为"天" "地"所生,所以"人"应该感谢和敬畏"天" "地".在旧中国,人与人之间的关系都是 "上下" "主从"的垂直关系,如皇帝官民关系,父子,夫妇,师生,长幼等关系,而所有这些关系都是不能颠倒的,妇女地位在旧中国处于最下下层,必需 "三从",即 "在家从父", "嫁后从夫", "夫死从子". 似乎**没有两个人可以处于完全平等的地位**,不知道两双胞胎之间是否能有完全平等的地位.**没有平等就很难产生自由的思想和行为**.任何人都不能 "犯上".所以这些出自圣贤教导和制定的纲常和礼仪完全禁锢了旧知识分子和中国人的思想和行为,使他们只有服而从不可能违背 "天意", "上意"和 "圣贤的教导",对自然界和事物进行观测和探究.这种流毒还多少残留在现代中国知识分子的思想中.

(H). 然而, 现代科技的高速度发展已给西方国家的民众带来了丰富的物质和文化生活. 一方面,人们能花更多的时间以满足自己的精神和文化的需要. **在过去,大多数人的困苦主要来自生活物品的缺乏. 在现代, 西方国家的民众的不幸福主要来源于个人欲望的恶性膨胀而不是生活的贫困,**结果导致个人犯罪的大量发生,而执政者个人欲望的恶性膨胀是导致霸权主义和国际战争的根源.这是西方文化传统中过分强调个人主义和个人自由的结果. 因此,人们就更需要正确的世界观和人生观以避免自寻烦恼和灾难从而害己害人害社会.不幸的是西方的流行文化已成为牟利的有效工具而大肆宣扬和美化暴力和犯罪.另一方面,资本家为了获取超额利润或暴利以满足自己的欲望,常造成环境污染而危害人类社会.西方发达国家的垄断资本集团及其政府在经济全球化的名义下,为了私利在国际间实行霸权主义,对发展中国家实行掠夺,造成国际间的冲突和战争,这是毁灭地球文明的真正的危险因素.难道世界的永久和平是靠核威慑的平衡达到呢还是靠道义的力量达到呢? 这就是说, 光靠发展科技和经济不能解决上述重大问题,而应该从中国文化的一些好的传统中寻找解决方法.在现在地球村的时代,各种文明冲击的最终结果必然是彼此之间取长补短的溶合发展. 例如,**中国在几千年的历史中从未发动过对外掠夺财富的战争.另外,中国近代革命史上有一种非常重要而有趣的现象,无论康有为,孙中山和毛泽东的革命目的和手段有多么大的区别,他们的最终目的都是要建立一个 "大同世界",而不是一个世界超级霸权.** 这就是中国文化好的传统与西方文化现行传统的大不相同之处.

(I). 文化是一个国家或民族的灵魂. 社会经济的发展一定会影响甚至改变该国家或民族民众文化生活和精神状态,即民众的内心世界,生活习惯,思想和行为的方式等. 然而,影响总是有正反或好坏两方面同时发生. 总而言之,随着科技和经济的快速发展,全社会民众的物质生活是日益丰富了. 相反,民众的道德品质在总体上是下降了. 这种结果可能是来源于西方文化中一些固有的缺点,因为西方文化将个人主义,个人利益,个人自由等放在第一位. 一个充满物欲而缺少道德偶像和偶像崇拜的文化可以说是一种病态的表现,对青少年的影响特别的坏.

由此可见, **西方文化是以个人和以物质利益为中心的.相反, 中国文化是以社会和道德为中心.两者各有所长和所短.** 西方文化有利于发挥个人的才能智慧和创造性,同时易于导致个人欲望的恶性膨胀和个人犯罪. 中国文化则偏重于 “修身,齐家,治国,平天下”这一套规范,使人的思想行为社会化政治化,从而限制了个人才能智慧和创造性的发挥.可见, 西方文化和中国文化似乎是走了两个极端.**值得回味的是中西文化的始祖孔子和亚里士多德都主张 “中庸之道”,**因此,在现代,中西文化各自的相互取长补短的溶合是必然的趋势.然而,中国文化是多有包容性而少有排斥性的,古代中国文化就以吸纳了印度的佛教而将其中国化,实际上,中国现在已经迅速地大量地吸纳了西方文化,特别是中国现代语言文字的西化已相当成功.因此, **中国文化吸收西方文化和其它文化正如顺水行舟**.而西方文化中浓厚的个人英雄主义和丛林法则等所产生出的优越感和排斥性使其过去和将来都较难吸纳了其它文化的优点.因此, **西方文化吸纳了其它文化的优点就象逆水行舟了**,只能费力地被推动着缓慢前进. **这或许是中国现代化的发展可能较快地赶上西方发达国家的重要原因之一.**

概括而言,中西文化的主要差异就是: 中国文化重“义” 轻“利”,而西方文化则重 “利” 轻“义”.现在,科学技术的高度发展已将世界变成为一个地球村,人,集团,组织,国家和民族之间的关系已非常紧密,**各种现有的优良文化之间的冲击不可避免,而总的趋势是强势文化很难消灭弱势文化。因此，文化之间的冲突和斗争是会很激烈的。**但愿各种现有文化之间的冲突不会导致国际之间的大战,然而,各种文化相互取长补短的溶合是历史发展的必然趋势,**因为在这诺大而复杂的世界不可能只有一种单一的文化存在,人们期待着相互取长补短的溶合后的世界的各种文化更加具有包容性和更加光辉灿烂.**

----全文完----

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波包编缩

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内容提要：当我们说某一对象的状态“确定”时，可能有两种含义：一种是指该对象的状态客观上是确定的；另一种是指观察者对该对象的状态的主观认识是确定的。在“薛定谔猫”这一理想实验中，当猫已被置于箱中一小时，但箱盖尚未打开时，它的状态在客观上已经确定，但观察者对它的状态的主观认识还不确定。这时打开箱盖，猫的客观状态未变，但观察者的主观认识从“不确定”突变为“确定”。这原是一件极为平常的事情，只是由于概念混淆，人们把这一过程误解为：打开箱盖，猫的客观状态从“不确定”突变为“确定”，这才得出“猫的死活取决于‘人眼的一瞥’”的荒谬结论。与“波包编缩”有关的一切古怪结论都是由这一概念混淆引起的。

费曼构思了如下理想实验：如果在电子的双缝衍射实验中加上一个光源，放置在第一块隔板的后面的两条窄缝之间，使我们“看得见”每一个通过电子到底通过的是第一条缝还是第二条缝，则屏上的衍射图形就失去干涉条纹。如果移去光源，则又会重新出现干涉条纹。这种由于“观测”而导致的相干性消失的现象，就是“量子退相干”。本文改进了费曼所提出的实验，使它能实现，并断言实验结果将证明：“量子退相干”只是由于对测量过程的误解而产生的幻想。

费曼曾经把测不准关系表成：不可能设计出一种仪器，它能在双缝衍射实验中确定电子到底是经过哪一条缝，而同时又不扰动干涉图案。他还说：测不准原理以这种方式“保护”着量子力学。如果谁设计出这种破坏测不准关系的仪器，量子力学的大厦就将倒塌。如果我们的实验预言得到证实，则我们已经设计出推翻费曼所表达的测不准关系的仪器，从而使得量子力学不得不换一种存在方式。[New York Science Journal. 2009;2(1):47-56]. (ISSN: 1554-0200).

关键词：冯·诺依曼；测量理论；人眼的一瞥；量子退相干；测不准原理

1. 引言

“测量理论”是极富有哲学意味的量子力学理论，它涉及像“月亮在没有人看它时是否存在”这样的玄之又玄的问题，从而涉及玻尔与爱因斯坦这样的科学泰斗之间的“世纪的争论”。在本文中，我们不考察这些高深的哲学理论，仅通过概念分析，考察与测量过程有关的物理学问题。

2. 已知事件、未决事件与暧昧事件

我们考察过薛定谔猫，从这一理想实验得出结论：“箱中的猫处于半死半活状态”的怪异结论乃是对“概率”这一范畴的误解，“概率”原是在单个事件身上映射某一“事件的集合”的属性，却被误解为描写单个事件的属性的范畴了。

现在，我们从另一角度考察薛定谔猫，为此，我们把这一理想实验重述一遍：

把一只猫和一个扳机同置于一个钢箱中，扳机的构造如下：放入盖革计数器中的少量放射性物质在一个小时内有原子衰变和没有原子衰变的概率相等，如果它有原子衰变，计数器就产

生反应，并作用于一个连着一个小锤的继电器，使小锤打碎一个装有氢氰酸的瓶子，从而毒死关在箱中的猫。猫不能直接接触扳机，因此，如果一小时之内放射性物质没有原子衰变，猫就还活着。按照量子力学的哥本哈根诠释将得出结论："一个小时以后，钢箱中将有半只活猫与半只死猫混合在一起，或者模糊不清。"

从这一理想实验还可以申引出更怪异的结论：既然在被关进钢箱中刚过去一个小时的那一时刻，猫处于半死半活的状态，如果这时打开钢箱，则我们立刻能看到：猫的状态或者是已经死去，或者还活着。于是，猫的状态立刻发生突变，或者从半死半活的状态变成死亡状态，或者从半死半活的状态变成活的状态。在这两种情况下，都是从"不确定的状态"突变为"确定的状态"，导致这一突变的乃是我们的观察。于是，我们的观察引起了"猫的状态"的突变。一言以蔽之，猫的生与死决定于"人眼的一瞥"。

这个结论实在太神奇了，难道微观世界真的这样不可思议吗？不！微观世界并没有什么不可思议之处，问题出在人们对微观世界的理解上，这里有另一个概念混淆。

当我们说某一对象的状态"不确定"时，可能有两种含义，一种是对象的状态客观上不确定；另一种是我们作为观察者对该对象的状态的主观认识不确定。如果事前就知道某一对象肯定会进入某一状态，则该对象的状态在客观上确定之前，主观上就已经确定了，这种情况与我们考虑的问题无关。排除了这种情形以后，按照"确定"或"不确定"来划分，一个对象可以处于如下三种状态：

第一，客观上和主观上都确定的状态；

第二，客观上和主观上都不确定的状态；

第三，客观上已经确定，但主观上尚未确定的状态。

下面，我们把客观上的"确定"称为"决定"，把主观上的"确定"称为"明确"。对于我们所考察的三种状态来说，已经明确的状态一定是已经决定的，尚未决定的状态一定是尚未明确的。第一种状态已经明确（因此已经决定），我们称它为"已知状态"；第二种状态尚未决定（因此尚未明确），我们称它为"未决状态"；第三种状态已经决定，但尚未明确，我们称它为"暧昧状态"。

例如，将一颗骰子放在一个带盖的容器中摇动，当容器还在摇动时，骰子的状态（即它的哪一点朝上）是"不确定"的。这种不确定是客观上的不确定，是"尚未决定"，此时骰子处于"未决状态"。当容器不再摇动，骰子已经落定，但容器盖还没有打开时，骰子的状态是否确定呢？第一，骰子已经落定，从而它的状态已经"决定"；第二，容器还是封闭的，观察者看不到骰子，从而它的状态还不"明确"，此时骰子处于"暧昧状态"。在揭开容器的盖子以后，观察者看到了骰子出现的点数，从而骰子的状态不仅是"决定"的，而且也是"明确"的，此时骰子处于"已知状态"。

回到薛定谔猫，按照理想实验的已知条件，如果猫置于箱中恰好过了一小时，则会出现如下两种状态之一：第一，计数器中的放射性物质还没有原子衰变，从而猫还活着，第二，有了原子衰变，从而猫已经死去。在这两种情形下，猫的状态在客观上都已经确定，从而已经"决定"；但在箱子打开之前，我们作为观察者还不知道猫是死是活，从而猫的状态还不"明确"。

因此，这时猫处于“暧昧状态”。

如果这时打开箱子，则会出现如下两种状态之一：第一，计数器中的放射性物质还没有原子衰变，箱子一打开，猫将一跃而出。第二，已经有原子衰变，箱子一打开，我们见到一只一动不动的死猫。在这两种情形下，猫的生与死不仅在客观上确定了，而且我们作为观察者也已经知道了，从而猫的状态不仅已经“决定”，而且已经“明确”。因此，这时猫处于“已知状态”。

由此可见，在猫置于箱中恰好过了一小时的时候打开箱子，确实引起了“猫的状态”的突变，从“暧昧状态”变为“已知状态”。但是，在这一过程中，突然改变的不是猫的客观状态，而是观察者对猫的状态的主观认识，“人眼的一瞥”改变了观察者对猫的状态的主观认识，这又有什么神奇之处！

然而，如果我们混淆了“决定”与“明确”这两个概念，从而混淆了“暧昧状态”与“未决状态”这两种不同含义的“不确定状态”，问题可就复杂了。在猫置于箱中恰好过了一小时而箱子尚未打开的时候，猫本来处于暧昧状态，现在由于概念混淆而被误解为处于未决状态，从而上面的观察过程就被表述为“如果在猫置于箱中恰好过了一小时的时候打开箱子，‘猫的状态’将从‘未决状态’变为‘已知状态’。”从而必然得出结论：“猫的客观状态（生与死）决定于人眼的一瞥”。

于是我们看到，“猫的生死决定于人眼的一瞥”这一神奇的结论，原来也来自一个概念混淆。

3. 概率的观察效应

“不确定”与“概率”这两个用语密切相关。

按照概率这一用语本来的含义，当我们说“某一只猫 m 还活着的概率是 1/2。”的时候，我们指的是：

第一，存在某一猫的集合 G，其中有半数的猫还活着；

第二，m 属于猫的集合 G。

在薛定谔猫这一理想实验中，m 所属的猫的集合 G 可描述如下：设有 N 个（N 足够大）钢箱，每一个钢箱都在同一时刻置入一只猫和一个扳机，这些扳机的宏观状态完全一样，则这些钢箱中的猫的集合就是 G。按照薛定谔猫这一理想实验给出的条件，在这些猫置入钢箱中一个小时的时候，在其中 N 个扳机中有一半扳机中的放射性物质有原子衰变、另一半扳机中的放射性物质则没有原子衰变。

猫的集合 G 中，我们看到了一个动态的过程：活猫与死猫的比例将随时间不断改变，从而在“单个猫 m 属于猫的集合 G”这一条件下，“m 的状态的概率分布”也是随时间改变的：在刚置于箱中时，m 是活猫的概率是 1，是死猫的概率是 0。我们把这个概率分布记作(1, 0)；在置于箱中恰好过去一小时的那一瞬间，这个概率分布是(1/2, 1/2)，再以后，这个概率分布越来越接近(0, 1)。我们称概率的这种变化为概率的“常规变化”，

“m 的状态的概率分布”还有另一种变化。

为了表现这种变化，我们先引进另一个的“猫的集合”：设想在 G 中的 N 只猫被同时置于各自的钢箱中刚好过了一小时的时候，同时打开所有的钢箱，则我们将看到其中约有 N/2 只猫

还活着，这些“活猫”的集合记作 H。

另一方面，如果在刚好过了一小时的时候，打开猫 m 所在的箱子让观察者看见箱中的猫还活着，则“单个猫 m 属于猫的集合 G”这一条件将不再成立，对应地，m 从猫的集合 G 转移到 H，从而 m 的状态的概率分布从(1/2, 1/2)突变为(1, 0)。反之，如果观察者看到猫已经死去，则这一概率分布从(1/2, 1/2)突变为(0, 1)。

我们称概率的这种变化为概率的“观察效应”。

概率的常规变化不是描写单个猫的状态的改变，而是反映他所属的猫的集合的状态分布的变化；至于概率的观察效应，既不是描写单个猫的状态的改变，也不是反映某一猫的集合的状态分布的变化，它表现的仅仅是我们作为观察者的主观认识的一种突变。

在薛定谔猫的理想实验中，打开箱子引起了“猫的状态”的概率分布突变，乃是表现猫从“暧昧状态”变为“已知状态”。因此，其中的概率分布(1/2, 1/2)表现的不是“未知事件”而是“暧昧事件”，可见概率既能表现“未知事件”也能表现“暧昧事件”。

当波普尔说他“不反对关于单个事件概率陈述的主观解释，即解释为不确定的预见”时，当赖欣巴赫断言 “说概率对单个事件也具有意义是无害的、甚至有益的习惯，因为它引导人们对于将来作出评价”时，他们都只想到概率能表现“未知事件”，而没有想到概率也能表现“暧昧事件”。我们将看到，人们将为这种片面性付出高昂的代价。

“未知事件”与“暧昧事件”的共同特点是，它们在主观上都是不确定的。它们之间的不同则在于：“未知事件”在客观上是不确定的，而“暧昧事件”在客观上却是确定的。既然这两种“主观上都不确定的”事件都可以用概率来表现，我们可以断定：概率所表现的“不确定性”是主观的不确定性。更一般地说，“概率是一个主观的范畴。”

4. 波包编缩

现在我们考察概率的常规变化与观察效应两种变化在量子力学中的表现方式。

在大量电子组成的电子束中，我们可用一个位置与时间的连续函数来描写“电子的数密度（单位体积内的电子数目）”的分布运动。

光波是一个波动过程，由一个“波函数”来描写，这个波函数满足波动方程。把这个波函数表成复数形式，则其“模方”（绝对值的平方）给出光波的“能量密度”的分布运动。同样，电子束的固有电磁场——德布罗意波，也用一个波函数来描写，这个波函数满足薛定谔方程，它的“模方”给出“电子数密度”的分布运动。

如果一个电子束有N个电子（N足够大），e是其中的一个，在某一时刻，电子束中有n个电子在某一小区域Ω内，则根据概率的频率定义，该时刻e在Ω内的概率是n/N。当N个电子各自作轨道运动引起n变化时，概率n/N也相应地变化。在这种意义下，薛定谔方程描写了单个电子的“概率”的分布运动，这是概率的“常规变化”。

另一方面，量子力学的测量过程以一种独特的方式显示概率的“观察效应”。例如，在电子自旋的测量过程中，设 e 是电子束 A 中的某一电子，当 A 通过一个斯特恩-革拉赫装置时，分为 A_1 与 A_2 两束，A_1 中的每个电子的自旋的测量值都是 1（以 $\hbar/2$ 为单位），A_2 中的每个电子的

自旋的测量值都是–1。如果 e 落在 A_1 中，则我们测得其自旋的测量值为 1。在这次测量之前，我们作为观察者只知道 e 是 A 的一个成员，从而事件“e 的自旋获得测量值 1”的概率 p 不等于 1。经过这次测量，该事件的概率突然从 p 变成 1。概率分布的这种突变是一种“观察效应”，它是“观察者的主观认识的变化”。

用“量子力学态”取代“状态的概率分布”，上述结论就表成：量子力学态有两种类型的变化，第一类是“不连续的，非因果的和瞬时作用的实验或测量”，即所谓“波包编缩”；第二类是薛定谔方程所描述的“时间进程中的连续的和因果的变化”。在这里，第一类变化是概率的观察效应，第二类变化则是概率的常规变化。这一论点，正是冯·诺伊曼的测量理论的出发点。

冯·诺伊曼把测量过程分解为两个阶段，第一阶段是被测量的系综与宏观仪器的相互作用，第二阶段是观察动作。以上面对电子自旋的测量过程为例，第一阶段是电子束在斯特恩 - 革拉赫装置分裂，第二阶段是指定被观察的电子落在哪一电子束。第一阶段是一个客观过程，第二阶段则仅仅改变观察者的主观认识。“波包编缩”是指其中的第二阶段，因而纯粹是概率的观察效应。

冯·诺伊曼的测量理论有如下两个要点：

第一，量子测量导致“波包编缩”；

第二，波包编缩是由于观察者的“观察”。

对于其中的第二个问题，冯·诺伊曼的结论是：

A　观察者在测量终结时看到仪器指针的读数，是导致被测量的对象从不确定状态过渡到确定状态的决定性因素。因此，如果不提到人类意识，就不可能表述一个完备的、前后一贯的量子力学的“测量理论”。

有了上面对薛定谔猫的考察，我们立刻找到了冯·诺伊曼的这一命题的症结所在。

“观察者看到仪器指针的读数”确实是导致被测量的对象“从不确定状态过渡到确定状态”的决定性因素，但其中的“不确定状态”是指“暧昧状态”。不幸的是，在量子力学的哥本哈根诠释中，“暧昧状态”与“未决状态”这两种不同含义的“不确定状态”却恰好被混淆了，从而人们把冯·诺伊曼的命题理解为“观察者在测量终结时看到仪器指针的读数，是导致被测量的对象从‘未决状态’过渡到‘已知状态’的决定性因素。”从而得出结论：“被测量的对象的客观状态决定于人眼的一瞥”。这实在太古怪了。只是因为量子力学难以言喻的现状，才使得这一荒诞不经的结论成了量子力学中的一个解不开的死扣。用波普尔的话来说，冯·诺伊曼提出的测量理论导致了剪不断理还乱的“客观诠释和主观诠释纠缠在一起的乱丝”。

其实，早就有人提出这种“对波包编缩的主观诠释”，但大多数量子物理学家认为，这种诠释不仅否认了物理状态描述的客观性，而且使物理学成为心理学的一部分，从而威胁着物理学作为一门研究独立于人类之外的存在的科学本身。这种诠释的逻辑结论将是：“物理学家根本不是在研究自然界，而只是在研究自己的研究工作。”

果真如此吗？不！对波包编缩的主观诠释绝对不会否认了物理状态描述的客观性！问题归根结底还是在于人们对“概率”的误解，我们不妨借助于我们所熟悉的张三先生的健康情况的例子来阐明这一点。回到如下概率陈述：

“张三得心脏病的概率是 3%。”

这个陈述具有而且也仅具有如下含义：

第一，某一人群 E 得心脏病的比例是 3%。

第二，张三属于人群 E。

在这里，3%这一概率所表现的不是张三的健康情况，而是在张三身上映射人群 E 的健康情况。

如果有人调查某一地区的居民的健康情况，得到许多有关的统计资料，其中之一是“某一人群 E 得心脏病的百分比是 3%”。为了计算方便，为了应用概率论，人们在这一统计资料之外添加一个命题：“张三属于人群 E。”这样，上述统计资料才表成：“张三得心脏病的概率是 3%。”这个概率陈述有两个因素：第一个是客观因素；第二个是主观因素。如果对张三作体检得知他没有得心脏病，则他得心脏病的概率就从 3%突然降到零。这种概率的变化没有改变“人群 E 得心脏病的百分比是 3%”这一客观的统计资料，只改变了“张三属于人群 E”这一为了应用概率论而纯粹人为加上去的主观因素。不容置疑的是，这种改变不会损害“人群 E 得心脏病的百分比是 3%”这一统计资料的“客观科学的地位”。

同样，对于上面考察的电子束，实验事实是：“波函数给出落在小区域 Ω 中的电子的相对数目”。当人们把这一命题翻译成“波函数给出单个电子e落在 Ω 中的概率”时，就悄悄地引进了一位观察者，他恰好知道“e属于该波函数所描述的电子束”。如果经过一次测量，e转移到了另一个电子束，则这位观察者的主观认识改变了，相应地，命题“波函数给出单个电子e落在 Ω 中的概率”不再成立。尽管如此，这种主观认识的改变也不会损害“波函数给出落在 Ω 中的电子的相对数目”这一统计规律的“客观科学的地位”。

5. 量子退相干

在冯·诺伊曼的测量理论中，“波包编缩”还伴随着一种难以理解的客观过程——“量子退相干”，从而上面的第一个问题成了“量子测量怎样导致‘量子退相干’”的问题；而第二个问题则成了“量子测量为什么导致‘量子退相干’”的问题，这就使得冯·诺伊曼的测量理论，无论在数学方面还是物理方面都成了极为艰深的理论。如果说量子力学是物理学的难点，那么测量理论就是量子力学的难点。

为了不涉及那些令人望而生畏的数学公式，我们仅通过双缝衍射现象对冯·诺依曼的“量子退相干”的论点作一定性的描述。

在《费曼物理学讲义 III》一书中，作者构思了一系列理想实验，其中之一是：如果在电子的双缝衍射实验中加上一个光源，放置在第一块隔板的后面的两条窄缝之间，使我们“看得见”每一个通过电子到底通过的是第一条缝还是第二条缝，则屏上的衍射图形就失去干涉条纹。如果移去光源，则又会重新出现干涉条纹。这种由于“观测”而导致的相干性消失的现象，就是“量子退相干”。

我们看到，“量子退相干”完全是一种从不可靠的推理得出的“效应”，人们从来没有观察到它。奇怪的是，它却似乎从来没有受到怀疑。相反，哥本哈根学派的大师们立刻兴趣盎然地

解释这种效应。

波尔的“互补原理”对“量子退相干”作了如下解释：微观物体的运动具有粒子与波的双重属性，但在同一实验中二者是相互排斥的。在电子的双缝衍射实验中，测量粒子通过哪一条缝强调了电子的粒子属性，与粒子性互补的波动性便被排除了，从而导致干涉条纹的消失。

海森堡则用他的“测不准关系”对“量子退相干”作了如下解释：根据测不准关系，准确知道某一电子垂直于路径方向的位置，意味着不能准确知道该电子垂直于路径方向的动量，从而造成屏上干涉条纹的消失。费曼因此而把测不准关系表成：“不可能设计出这样的仪器，它能确定电子通过双缝中的哪一条缝，同时又不扰动干涉条纹。”

在冯·诺伊曼提出他的测量理论之后，量子物理学家们纷纷提出各式各样的新测量理论，试图阐述、补充或取代冯·诺伊曼的测量理论，而薛定谔却在这时提出“薛定谔猫”对这个理论对整个量子力学的现状提出质疑。

量子物理学家们关于“量子退相干现象”的意见可大致分成两种类型。

一种以冯·诺伊曼为代表，他在《量子力学的数学基础》一书中提出了或许是最早的测量理论，其中的命题 A 表明，“主观的介入”乃是量子退相干的根本原因，换句话说，量子相干性消失，归根结底是由于“人眼的一瞥”。

德国物理学家吉·路德维希则持的相反的观点，他拒绝“感觉”、“知识”和“意识”等用语出现在物理学中，并且把宏观仪器看成一个处于热力学亚稳态的宏观系统，把测量理解为宏观仪器受到微观系统的扰动向热力学稳态演化。因此，测量不再是“客体与主体之间的一个不可分的链环”，而是一个“微观系统与一个宏观系统之间的一个不可分的链环”。

意大利物理学家丹内里、朗格和普洛斯佩里在路德维希的工作的基础上建立了一种精致的测量理论，简称为 D-L-P 理论。按照这种理论，测量之所以导致量子态相干性的消失，是被观测的微观系统自身经历的一个具有“各态历经”特征的过程，并不需要“人眼的一瞥”。

在路德维希的工作的基础上建立另一种的测量理论是“退相干理论”，它把测量过程中量子态相干性的消失理解为由于“量子纠缠”而导致的一个动力学过程，即使观察者不在场也照样发生，其中仪器只不过起着“记录”的作用。

在这里，我们先不去考察这些复杂、精致而又引人入胜的测量理论，仅提出如下问题：能不能用实验来判定路德维希的观点与冯·诺伊曼的观点孰是孰非？

让我们回到费曼的关于“观察电子”导致干涉条纹消失的理想实验。在这个实验中，我们满可以放置上光源而不观察电子，如果实验结果是不出现干涉条纹，则测量过程要求“主观的介入”，如果实验结果是仍然出现干涉条纹，则测量过程不要求“主观的介入”。这是一个明确的判决性实验。

费曼本人没有对这一问题给出确切的回答。他一方面说：“也许这是由于点上光源而把事情搞乱了？……我们知道，光的电场作用在电荷上时会对电荷施加一个作用力。所以也许我们应当预期运动要发生改变。不管怎样，光对电子有很大的影响。在试图跟踪电子时，我们改变了它的运动。也就是说，光对电子的反冲足以改变其运动，……这就是为什么我们不再看到波状干涉效应的原因。”按照这种作用机制，只要点上光源，不论我们观察不观察电子，干涉条纹都

会消失。可另一方面，费曼又说：“假如电子没有被看到，我们就会发现干涉现象。”还说：“当我们观察电子时，它们在屏上的分布没有干涉条纹；当我们不观察电子时，它们在屏上的分布有干涉条纹。”照这么说，即使点上光源，只要我们不观察电子，干涉条纹就不会消失。

尽管如此，费曼的自相矛盾的回答并不妨碍我们借助于费曼的理想实验来判断路德维希的观点与冯·诺伊曼的观点孰是孰非，真正的困难在于如下事实：电子太小，我们不能在光的照耀下跟踪它。因此，还须作一些技术上的改进，我们才能实现费曼的这个理想实验。在这里，我们提出一个建议。

6. 一个关于“量子退相干”的实验预测

考虑一个连续地发射成对电子的电子源，让每一对电子都精确地朝相反的方向运行，从而形成相向运动的两个电子束 R 与 R’。现在，让 R 通过一个开有双缝的隔板 L，落在某一可以探测电子位置的屏上。同时，又让 R’中的电子飞向一个与 L 极对称的另一隔板 L’。这个隔板只有一条缝 S，它有如下性质：设 e 是 R 中的一个落在屏上的电子，e’是它在 R’中的配偶，则当且仅当 e 越过 L 的第一条缝时 e’会越过缝 S。这样，从 e’是否越过缝 S 我们就知道 e 通过的是 L 的哪一条缝。下面，我们把这个实验记作 T。

对于电子束 R，实验 T 是一个双缝衍射实验。而电子束 R’的行为，则代替了费曼的跟踪电子的光源。而“放置上光源而不观察电子，会不会出现干涉条纹”这一费曼理想实验实际上提出的问题现在转化为如下问题：

让 L 上的双缝同时打开，如果观察者跟踪 R’的每一个电子，看它是否通过缝 S，则观察者就间接地知道电子束 R 的每一个电子经过的是哪一条缝，从而按照费曼的意见，有：

B　如果观察者跟踪 R’的电子，则干涉条纹将消失。

那么，如果其它条件不变，只是观察者不再跟踪 R’的电子，干涉条纹会不会消失呢？

按照冯·诺伊曼的意见，由于没有观察者的跟踪，对 R’的电子的测量就少了“人眼的一瞥”这一决定性的最终环节。在这种残缺不全的测量过程中，该电子不会从“不确定状态”过渡到“确定状态”，从而屏上的干涉条纹不会消失。因此，

C　只要观察者不跟踪 R’的电子，干涉条纹就不会消失。

反之，如果测量是“微观系统与一个宏观系统之间的一个不可分的链环”，则有

D　R 在屏上的干涉条纹会不会消失，只与客观的实验条件有关，与观察者是否知道 R’的电子的行为无关。

从命题 B 与命题 D 得出结论：

E　即使观察者不跟踪 R’的电子，干涉条纹也会消失。

这就是路德维希的意见，也是 D-L-P 理论与“退相干理论”的出发点。

于是，如果实验 T 的结果是 B，则路德维希的观点是错误的；如果实验 T 的结果是 D，则冯·诺伊曼的观点是错误的。由此可见，实验 T 的结果至少会“证伪”上述两种观点中的一种。

然而，虽然 B 与 D 相互排斥，C 与 D 却可以同时成立。因此，即使实验 T 出现了结果 B，也仅仅否定路德维希所预期的结果 E，却并未否定路德维希的基本观点 C。如果仍然坚持 C，

则从实验结果 B 将得出结论：命题 B 不成立。换句话说就是

F　即使观察者跟踪 R’的每一个电子，从而知道了 R 的每一个电子到底是经过哪一条缝，屏上仍然会有干涉条纹。

这是实验 T 可能出现的第三种结果。这种结果对量子力学来说意味着什么呢？

费曼曾经把测不准关系表成：不可能设计出一种仪器，它能在双缝衍射实验中确定电子到底是经过哪一条缝，而同时又不扰动干涉图案。他还说：测不准原理以这种方式“保护”着量子力学，如果谁设计出这种破坏测不准关系的仪器，量子力学的大厦就将倒塌，量子力学就以这样的冒险而又准确的方式继续存在着。

如果实验 T 出现了第三种结果 F，则它所用的仪器就是费曼所说的破坏测不准关系的仪器，从而给量子力学带来灾难。诚然，即使出现了这样的灾难，倒塌的也不是量子力学的形式体系，而只是费曼们对量子力学的诠释。

实际上，上面提到的各种测量理论，都确认一个前提：在实验 T 中，命题 B 肯定成立：如果观察者跟踪 R’的电子，则干涉条纹将消失。而干涉条纹的消失，则起源于对电子束 R’中的电子的观测，只不过对于不同的测量理论，被观测的电子将经历不同的过程。对于冯·诺伊曼测量理论来说，它是最终由于“人眼的一瞥”而导致的一个从不确定状态过渡到确定状态的过程；对于 D-L-P 测量理论来说，它是由于被观测的电子自身的“各态历经”而导致的一个统计力学过程；对于“退相干理论”来说，它是由于“量子纠缠”而导致的一个动力学过程。所有这些理论都要求 R’的电子与其 R 中的配偶有某种神秘的“非定域关联”。因此，如果爱因斯坦还活着，我想他会期待实验 T 出现第三种结果 F，因为这种结果有利于他心爱的“定域性原理”。

我预言：实验 T 肯定会出现结果 F，其根据不是高深的“定域性原理”，而是如下极为平凡的推理：

从费曼关于退相干现象的阐述我们看到，问题起源于双缝衍射实验的如下实验结果：

G　双缝同时打开时的衍射图形不是双缝轮流打开时的两个衍射图形的迭加。

人们认为，这一实验事实表明电子的运动不是轨道运动，从而我们不能断言某一电子究竟是通过哪一条缝达到屏幕上的。如果关闭一条缝，我们就得到确切的信息，电子肯定是通过另一条缝通过的。但为此我们付出了代价：干涉条纹消失了。于是得出一般结论：测量导致干涉条纹消失，再向前走一步就得出量子退相干的一般理论。

在我看来，实验事实 G 并不表明电子的运动不是轨道运动，而仅仅表明电子通过某一条缝的运动与另一条缝的启闭有关。从电磁学的角度来说，这一见解不难理解：电子自己有一个固有电磁场，开启或关闭另一条缝，将会改变电子的固有电磁场的边界条件，从而间接改变电子的运动。按照这种见解，从双缝衍射实验并不能得出“测量导致量子退相干”的结论。

实验T可以有各种变形，例如用电子通过斯特恩 - 革拉赫装置的不同通道来取代电子通过不同的缝，这样，被观测的物理量就不再是电子的位置而是电子的自旋。或许，这种观测电子自旋的实验更容易实现。

我在等待大自然的裁决。

7. 结束语

“量子退相干”是冯·诺依曼的测量理论的出发点，也是其他测量理论的出发点。如果 T 实验果真出现第三种结果，整个测量理论就成了空中楼阁。至少在这一领域里，与量子力学相联系的一切高深莫测、玄之又玄的哲学理论都成了空谈，至于与此有关的“新的实验事实”，则有待重新解释，不再与测量理论有关。

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Wave packet collapse

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Abstract: The proposition that the state of some substance is certain has two meanings: one is that the state of the very substance is certain objectively; the other is that the subjective cognizance of the observer on the very substance is certain. In the idea experiment Schrodinger’s cat, if after the moment that the cat is put in the box in an hour, open the box top, then the objective state of the cat preserve unchanged, but the cognition of the observer transforms from uncertain state into certain state. That is quite an ordinary event; only because of a concept confuse, this event is misunderstood by the event that open the box top, the objective state of the cat transforms from uncertain into certain, it is thus concluded that the cat’s state is decided by “a glance of the personal eye”. All of the eccentric outcomes are caused from this concept confusion.

Feynman conceived the following idea experiment: Putting a light source in a double slit diffraction experiment about electrons and placing it behind two slit such that the observer can see which slit an electron passes through, then the interference streak on the screen will vanish. Removing the light source, the streak will appear again. In other words, interference vanishes originates from the “observing”. Such a phenomenon is called “quantum vanishing of coherency”. Feynman’s idea experiment is improved such that it is able to be realized. Still further, it is predicted that the result will proved that “quantum vanishing of coherency” is only an illusion originated from a misunderstanding about measurement processes.

Feynman expressed uncertainty principle as the form that it is impossible to make designs for an instrument, which is able to inform which slit an electron passes through, as well as preserve the interference pattern unchanged. Still further, he said that in such a way uncertainty principle safeguards quantum mechanics. If some one designs an instrument violated uncertainty principle in this form, the building of quantum mechanics will collapse. If my experimental prediction is verified, then such an instrument has been designed, and thereby quantum mechanics has to exist in another fashion.

Key words: Von. Neumann; measurement theory; a glimpse; vanishing of coherency; uncertainty

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内容提要：如果把某一硬币一再地随手一掷，则它一会出现正面，一会出现反面，当我们多次掷硬币时，就会出现如下统计规律：大约有一半出现正面，一半硬币出现反面。掷硬币的次数越多，出现正面的次数与出现反面的次数就越趋于相等。在这种意义下我们说：在大量“掷硬币事件”中，出现正面的“相对频率”是 1/2。在同样的意义下，我们也可以说：单独掷一次硬币，该硬币出现正面的“概率”是 1/2。这一命题只是前一命题的一种“观念的反映”，而前一命题则是这一命题的“现实原型”。

按照波函数的概率诠释，波函数所给出的“概率分布”也是一种“观念的反映”，其“现实原型”则是大量电子所组成的电子“系综”的“统计分布”。可是，在某些场合波函数描写的对象却是单个电子。哥本哈根学派因此而误解了“概率”这一用语的含义，把“概率分布”误解为一种“现实的分布”，这种误解无异于说：单独掷一次硬币，该硬币出现半个正面和半个反面。由于波函数仅出现在微观世界，因此这种误解的范围仅限于微观世界，对于宏观世界，哥本哈根学派还保持着对概率的通常的理解，我把这种独特而又有限的对概率的误解，称为“哥本哈根迷误”。由于仅限于微观世界，“哥本哈根迷误”并不显得过分荒谬。

不幸的是，“薛定谔猫”这一理想实验，把原子衰变这一微观事件与猫的死亡这一宏观事件联系起来，使得“哥本哈根迷误”在宏观世界显现出来：当猫被置于箱中一小时以后，猫的状态的概率分布是：“猫死去的概率是 1/2，活着的概率也是 1/2。”这一概率分布的本来含义是：如果有大量的薛定谔猫，在同一时刻被置于有相同的装置的钢箱中，则过了一小时以后，大约有一半猫死去，一半猫还活着。由于哥本哈根迷误，人们不得不把这一概率分布理解为“一小时以后，箱中的猫是半个死猫与半个活猫的混合物”。这样，薛定谔就充分揭示了量子力学的“哥本哈根诠释”的荒谬性。
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关键词：薛定谔猫；不确定性；概率分布；波函数；哥本哈根迷误

引言

1935 年，薛定谔提出了一个现在称为“薛定谔猫”的理想实验，对量子力学的哥本哈根诠释提出质疑，其大意如下：

把一只猫和一个扳机同置于一个钢箱中，扳机的构造如下：放入盖革计数器中的少量放射性物质在一个小时内有原子衰变和没有原子衰变的概率相等，如果它有原子衰变，计数器就产生反应，并作用于一个连着一个小锤的继电器，使小锤打碎一个装有氢氰酸的瓶子，从而毒死关在箱中的猫。猫不能直接接触扳机，因此，如果一小时之内放射性物质没有原子衰变，猫就还活着。按照量子力学的哥本哈根诠释将得出结论：“一个小时以后，钢箱中将有半只活猫与半只死猫混合在一起，或者模糊不清。”

据说这个理想实验使某些量子物理学家们极为困惑、愤怒甚至憎恨，以至于“希望薛定谔猫死去”，“像恐怖电影那样从视线中消失”，鼎鼎大名的霍金听到薛定谔猫的时候，“忍不住要去拿他的枪了。”

为什么薛定谔猫这个理想实验会如此招人憎恨呢？

一个语义上的错位

我们即将看到，薛定谔猫所揭示的问题与概率的概念密切相关，因此，在考察薛定谔猫之前，让我们先考察“概率”这一用语。

如果谁经常作概率论教程中的习题，他就会知道，概率实际上是对单个事件而言的；但是，与概率有关的统计规律，却是关于一系列事件的规律。这一事实使得概率这一用语具有颇为曲折的含义，让我们先考虑一个最简单的关于统计规律与概率的例子。

如果把某一硬币一再地随手一掷，则它一会出现正面，一会出现反面；但是，当掷的次数增多时，出现正面的次数与出现反面的次数将趋于相等；在任意给定的场合，当掷的次数足够多时，就可以认为出现正面的次数与出现反面的次数是相等的（即可以忽略出现正面的次数与出现反面的次数之间的微小差别）。

一枚硬币掷出并落定以后，可以拾起来再掷，这种情形使得上述事实作为统计规律的例子有一定特殊性。为了适用于更一般的情形，我们把它改写成为如下形式：

事实 1：如果把大量硬币随手一掷，则其中的有些出现正面，有些出现反面；但是，当掷的硬币足够多时，就可以认为出现正面的个数与出现反面的个数是相等的。

按照习惯，把“正面”或者“反面”称为硬币落定以后的“状态”，把相对频率的分布称为“统计分布”；用 G 表示在事实 1 中的“掷出并落定以后的大量硬币”的集合，再用(1/2, 1/2)表示“正面占 1/2；反面占 1/2”这一状态的“分布”，则事实 1 可表成：

G 中诸硬币的状态的统计分布是(1/2, 1/2)。

如果观察者知道而且也仅知道“a 是 G 是的一个元素”，则事实 1 也可表成：

a 的状态的概率分布是(1/2, 1/2)。

现在我们问：概率分布(1/2, 1/2) 所表现的到底是硬币的集合G的特征还是单个硬币a的特征？为了不受“概率”这一用语的先入为主的影响，我们先考虑如下两个命题的含义：

第一，分布(1/2, 1/2)表现集合 G 的特征；

第二，分布(1/2, 1/2)表现单个硬币 a 的特征。

第一个命题表示“在 G 中的大量硬币中，约有一半是正面，一半是反面。”这一点不会有疑义，但第二个命题就复杂多了。

阐明第二个命题的含义意味着回答如下问题：“某种分布，它描写单个硬币 a 的状态，一半是正面，一半是反面，怎么理解这一分布所描写的硬币 a 的状态？答案是一目了然的：“硬币 a 出现的状态是半个正面，半个反面！”

经验事实是：G 中的大量硬币确实约有一半出现正面，一半出现反面，因此统计分布(1/2, 1/2)表现集合 G 的特征；但 a 或者出现正面，或者出现反面，不会出现半个正面半个反面，因此，

分布(1/2, 1/2)所表现的并不是 a 的特征，这一点是丝毫不能含糊的。

但是，分布(1/2, 1/2) 作为G的特征，乃是G中的诸硬币的状态的“统计分布”，而不是它们的“概率分布”。事实上，根据概率的频率定义，事实 1 只能表成：“将一个硬币随手一掷，它出现正面的概率是 1/2。”在观察者恰好知道“a是G的一个元素”的前提下，这种陈述乃是用“概率”这一用语表现事实 1 时唯一可能的方式。如果在命题B中用G取代a，从而改写成“G的状态的概率分布是(1/2, 1/2)。”，它就不再是对事实 1 的陈述了。因此，从语义上说，作为概率分布，(1/2, 1/2)被看作是a的状态分布，这一点也是丝毫不能含糊的。

总之，从语义上看，命题 B 中的“概率分布”似乎描写了 a 的特征，但事实上，a 不会出现半个正面半个反面，从而并不具有分布(1/2, 1/2)所描写的特征。于是，我们有：

作为概率分布，(1/2, 1/2)是 G 的特征而不是 a 的特征，但(1/2, 1/2)却是 a 的概率分布而不是 G 的概率分布。

这是“概率”这一用语所固有的语义上的错位。这种错位使得概率分布(1/2, 1/2)、a 和 G 三者的关系极为微妙，我们把这种微妙的关系表成：“概率分布(1/2, 1/2)是在 a 身上映射 G 的特征量”。由此得出结论：

一个事件的概率，不是该事件的属性，而是在该事件身上映射一个“事件的集合”的属性。

这个命题不仅难懂，而且说起来也不清爽，简直像一个绕口令。然而，我们即将看到，这个命题却是理解“概率”这一用语的关键，是解开量子理论中的众多疑难的一把钥匙。

科学哲学家赖欣巴赫曾对概率的含义作过一个如下表述：“给个别事件以一个概率度是没有意义的，因为一个事件不能用一个概率度来计量。”但接着他又承认：“说概率对单个事件也具有意义是无害的、甚至有益的习惯，因为它引导人们对于将来作出评价，只要这种语言被翻译成一个关于一系列事件的陈述。”赖欣巴赫还说，逻辑学家可以把这种表达方式“视为具有虚构意义，代表着一种省略的说话方式……它只因为能被翻译为另一种陈述才是有意义的。”

赖欣巴赫在这里实际上已经弄清了“概率”这一用语所导致的上述语义上的错位，只可惜他混淆了“相对频率”与“概率”两个概念，从而表达得不够确切。按照我们的用语，赖欣巴赫的命题可表述如下：

“概率’与‘相对频率’是同一个比值，但‘相对频率的陈述’是对一系列事件的陈述；而‘概率的陈述’则是对单个事件的陈述。‘概率的陈述’本身就是一种省略的说话方式，它只因为能被翻译为‘相对频率的陈述’才是有意义的。”

概率分布不是一种“现实的分布”

我们考察过如下电子的小孔衍射过程：电子源不断向一个小孔发射电子，其中有N个电子通过小孔落在屏幕上，在这N个电子中，有n个落在屏幕上的一个小区域Ω上。实验证明：当N足够大时，比值n/N将达到某一稳定值p，这个稳定值被称为N个电子落在 Ω上的“相对频率”。用A表示落在屏幕上的N个电子的集合，则相对频率p是系综A的属性。若已知e是A的一个元素，则e落在Ω上的概率为p。

如果把屏幕分割成s个小区域，用p_j表示N个电子落在第j个小区域Ω_j上的相对频率，则我们

得到一个相对频率的有限序列

$$\{p_1,p_2,\ldots\ldots,p_s\}。$$

当屏幕上的小区域分得足够细时，这个序列就给出 A 的诸电子的位置的“统计分布”，实际上，“统计分布”就是“相对频率”的分布。相对频率与观察者无关，因此统计分布也与观察者无关，从而统计分布是一个客观的范畴。

另一方面，若已知e是某一落在屏上的单个电子，则p_j表示电子e落在第j个小区域Ω_j上的概率，s个概率$p_1,p_2,\cdots\cdots,p_s$给出“单个电子e落在屏幕上的诸位置的概率分布”。

按照量子力学的用语，一个微观物体称为一个“系统”，大量系统的集合称为一个“系综”。例如，在电子衍射实验中，一个电子就是一个微观系统，落在屏上的电子的集合就是一个系综。电子的衍射图形显示了这些电子的统计分布。衍射图形乃是落在屏上的大量电子这一系综的属性，因此，屏上大量电子的统计分布乃是这个系综的属性。

但是，“单个电子 e 落在屏幕上的诸位置的概率分布”这一命题的主词不是“系综 A”而是“单个电子 e”，它是系综 A 的一个元素。因此，如果说“统计分布”是“系综”的一种物理属性，那么，“概率分布”却不是。把命题 D 应用在这里，我们得出结论：

概率分布既不是系综的物理属性，也不是系综的元素的物理属性，而是在单个元素的身上映射系综的物理属性。

将这一命题应用于电子衍射过程可得出结论：一个电子落在屏幕上某处的概率，不是该电子的属性，而是在该电子身上映射落在屏幕上的诸电子的集合的属性。更一般地说，某一系统处于某一状态的概率，不是该系统的属性，而在该系统身上映射某一系综的属性。

回到掷硬币的过程。当我们一次掷出的大量硬币时，在误差允许的范围之内，其中有一半硬币是正面、一半硬币是反面，因此（1/2, 1/2）这一统计分布乃是这个“硬币的集合”自身的一个属性。而对于其中的单个硬币来说，（1/2, 1/2）这一概率分布并不意味着这个硬币的图案中有一半是正面、一半是反面，从而它不是这个硬币自身的一个属性。按照我们的用语，（1/2, 1/2）这一概率分布是在这个硬币身上“映射”大量硬币的“统计分布”。在这种意义下我们说：“概率分布”是“统计分布”的“观念映像”；而“统计分布”则是“概率分布”的“现实原型”。从而有：

“统计分布”是一种“现实的分布”，而“概率分布”则是一种“观念上的分布”。

某些读者或许不习惯“现实的分布”和“观念上的分布”这一对用语，觉得它们“语焉不详”。对于这部分读者，不妨把命题 F 中的这一对用语理解为如下硬性的规定：命题“(1/2, 1/2)作为单个硬币的概率分布是一种现实的分布”是指“单个硬币出现半个正面、半个反面的图案”；而命题“(1/2, 1/2)作为单个硬币的概率分布是一种观念上的分布”则是说：“单个硬币的概率分布是(1/2, 1/2)”只不过是“大量硬币的统计分布是(1/2, 1/2)”的另一种说法。

另一领域中的一个语义上的错位

其实，像“概率陈述”这样的语义上的错位并不是数理科学所特有的，社会科学也有类似的情形。

改革开放以后，我国思想界开始怀疑马克思主义，例如，一位颇负盛名的思想家对马克思的劳动价值论提出如下质疑：

“（按照劳动价值论，）一个产品的价值，就以制造这个产品所需要的社会平均必要劳动时间来衡量。比如造一张桌子，甲要三天时间，乙要两天时间，丙要一天时间，那么制造这张桌子的社会平均必要劳动时间就是两天，这就是它的价值。这个理论，是以体力劳动为基础的。应用到简单劳动上，好像没有什么问题；应用到复杂劳动上，就有些困难；应用到单纯的脑力劳动上，特别是创造性的脑力劳动上，就完全不行了。体力劳动的产品，是可以规格化的。甲乙丙三个工人造出的桌子，必须是一样的，这样才好比较，才好用数字来计算。但是脑力劳动的产品怎样比较？怎样计算？鲁迅写《阿 Q 正传》，该给多少报酬才是不多不少？如果有另外的张三和李四，也写出了《阿 Q 正传》，一模一样，那就好办，可以把三个人所花的写作时间平均一下。但《阿 Q 正传》是独一无二的，别人写不出来，那么就没有什么社会平均劳动时间。”

我在这里如此详尽地引用这一段话，是因为这位思想家的思路，与哥本哈根学派的量子物理学家们的思路在某一点上相似，确切地说，这两种思路有相同的失误。

顺便说一句，如果造一张桌子，甲要三天时间，乙要两天时间，丙要一天时间，那么对这三个人而言，制造这张桌子的平均劳动时间并不是两天。这一问题涉及计算平均值的技巧，我不怀疑这位思想家完全能掌握这种技巧，在这里他肯定是疏忽了。下面，让我们撇开这一令人烦恼的细节问题，直接考虑马克思的劳动价值论中的“价值”概念。

对于马克思的劳动价值论，“价值”乃是概念王国中的一个陷阱，这位思想家不幸掉进这个陷阱里了。

按照马克思的劳动价值论，如果对于某一社会，人们制造一张桌子需要的平均时间是 s，则对于该社会来说，s 就是一张桌子的价值。因此，如果该社会中的某一木匠制造了一张桌子 a，不论花了多少时间，a 的价值就是 s。但为了计算出 s 这一平均值，不能仅考虑 a 这张桌子，而必须考虑在一定时期内该社会的木匠们所生产的全部桌子 T。用一个数学用语，我们必须考虑 T 这个“桌子的集合”，s 这一平均值乃是 T 的一个“特征量”，或者说 s 是 T 的一个“属性”。

这里出现了一个“语义上的错位”：s 是一张桌子 a 的价值，却不是 a 的属性；它是某一“桌子的集合”T 的属性，却不是这一集合的价值。由于这一错位，“价值 s”、“桌子 a”和“桌子的集合 T”这三者也处在一种极为微妙的关系中。我把这一关系表成：“s 作为‘价值’乃是某一‘桌子的集合’T 的属性，却是在单个桌子 a 身上映射出来。”由此也得出一个绕口令般的结论：

“一个商品的价值，不是该商品的属性，而是在该商品身上映射某一‘商品的集合’的属性。”

这个命题也难懂也不清爽，但为了回答这位思想家所提出的问题，却必须弄清楚这一命题。根据这一命题，鲁迅的“阿 Q 正传”作为一件商品，其价值并不是“阿 Q 正传”这本书的属性，而是某一“书的集合”的属性，只不过这一属性在“阿 Q 正传”这本书上映射出来。诚然，指出这一点，还远不能确定“《阿 Q 正传》该给多少报酬才是不多不少”，这里还有一团乱麻有待理清；但是，那位思想家就再也不能得出“《阿 Q 正传》没有什么社会平均劳动时间”的结论

了。

我们看到，量子物理学家们把“概率”误解为一个事件自身的属性，在这里，我们又看到，这位思想家把“价值”误解为一件商品自身的属性；这两种误解倒是异曲同工。

概率诠释与电磁诠释

按照波函数的概率诠释，波函数所描写的对象本来是大量电子所组成的“系综”，可是哥本哈根学派的理解，波函数所描写的对象却是单个电子，这样就把“波函数给出的概率分布”误解为一种现实的分布了。那么，哥本哈根学派为什么会认为波函数描述的是单个电子呢？

量子力学的诠释的基本问题是，怎么理解薛定谔方程中的“波函数”。由于薛定谔方程最初是从氢原子中的单个电子行为得到的，因此，这个问题的最初的形式是问：“薛定谔方程中的‘波函数’对于单个电子有什么物理意义？”

玻恩与薛定谔是一对挚友，他们在令人羡慕的友情交往中争论了一生，争论的中心点就是波函数对于单个电子的物理意义的问题。遗憾的是，两个人都没有发现，他们为之争论的“单个电子”各有各的含义。玻恩根据他所考察的“碰撞过程”给出了“波函数的概率诠释”，这种碰撞过程涉及大量电子，而所谓“单个电子”则是指大量电子中的一个；而薛定谔则根据他所考察的氢原子中的单个电子建立了薛定谔方程，在氢原子中没有大量电子，单个电子是指“孤立的单个电子”，而不是指大量电子中的一个。我们即将看到，弄清这两种“单个电子”的之间的区别是至关重要的。

为了言简意赅，我们称大量电子中的单个电子为“群电子”，称孤立的单个电子为“孤电子”。“群电子”与“孤电子”都是单个电子，但它们是不同含义的单个电子。在玻恩考察的碰撞过程中，所涉及的单个电子是“群电子”，而薛定谔所考察的则是氢原子中的“孤电子”。既然薛定谔通过对氢原子中的孤电子的描述给出波函数所满足的薛定谔方程，波函数对孤电子肯定是有意义的。然而，只有对于群电子，单个电子的状态的概率分布才能观念地映射大量电子的状态的统计分布。对于孤电子，没有作为原型的“统计分布”，也就没有作为观念映像的“概率分布”了。

人们或许会问：热力学所研究的“热力学系统”并不是大量的全同的热力学系统中的一个，在这种意义下它是一个“孤立的单个系统”，而根据吉布斯的系综中的单个系统却是“大量系统中的一个”。按照上面的用语，前者是“孤系统”，后者是“群系统”。按理说，对于孤系统，没有作为原型的“统计分布”，也就没有作为观念映像的“概率分布”了。为什么我们却可以为这个孤系统定义吉布斯系综的概率分布函数呢？在这里，人们把电子与热力学系统相比，这一类比是不恰当的。

以热力学中的某一闭系统为例，闭系统是一个与大热源接触的系统。其对应的微观系统是一个与外界交换能量但是不交换粒子的力学系统，该系统是一个“孤系统”。但是，我们可以在想象中大量复制这个系统，这些复制成的系统具有相同哈密顿量，把这些复制成的系统用“导热管”连接起来，形成一个闭系统的集合，它就是“吉布斯正则系综”。该系综中的任一系统都是一个“群系统”，只要我们把这个群系统以外的其他系统当作该系统的“大热源”，这个群系

统就完全等同于所考察的闭系统了。因此，我们所考察的闭系统虽然是一个“孤系统”，但它可以等同于一个“群系统”，我们可以对这个群系统定义一个“概率分布函数”，它是吉布斯系综的“统计分布函数”映射在该群系统身上的观念映像。

那么，对于一个“孤电子”，我们能不能在想象中大量复制它，形成一个“电子系综”，让该电子等同于该电子系综中的一个成员呢？回答是否定的。因为根据已知的量子力学原理，我们不能模仿吉布斯系综的方式来复制我们所需要的“电子系综”中的成员。

以氢原子中的孤电子为例，如果我们在想象中大量复制该电子，使得波函数的模方与这些电子的数密度成正比，则在氢原子核周围将有大量电子，而根据“泡利不相容原理”，这是不可能的。诚然，我们也可以在想象中大量复制氢原子本身，从而复制了大量各自绕一个氢原子核旋转的电子。这样得到的大量电子就不是处在“同一”外部条件下的电子而是处在“相同”的外部条件下的电子。问题在于，这些处在“相同”的外部条件下的大量电子与波函数有没有关系。

为了回答这一问题，让我们考虑最简单的“单色的电子束”，这种电子束诸电子在空间均匀分布。但如果我们大量复制一个作等速直线运动的孤电子，这些在想象中被复制出来的电子不是处在“同一”外部条件下而是处在“相同”的外部条件下，那么这些电子未必会在全空间均匀分布，相反，它们在空间的分布可能是这样的：第一个在北京海淀，第二个在上海浦东，第三个在纽约曼哈顿，而第四个则在天狼星上。因此，一般地说，要一个电子束的数密度与波函数的模方成正比，诸电子必须处在“同一”外部条件下而不是处在“相同”的外部条件下。

对于热力学中的闭系统，我们也可以用如下方式在想象中复制它：把它的微观状态在一段很长的时间内所经历的各种状态作等时距抽样：将这一段时间分成相等的 n 个时间间隔并取其中点，就得到 n 个时刻，把该闭系统在这 n 个时刻的状态想象成 n 个闭系统在同一时刻的状态，就会得到的一个“闭系统的集合”，该集合给出一个吉布斯系综。显然，这样得到的吉布斯系综自然地满足如下基本假设：所考察的闭系统的某一物理量的“长时间平均值”等于其吉布斯系综的“系综平均值”。

那么，能不能对一个孤电子的运动作等时距抽样形成由波函数描写的电子系综呢？回答也是否定的。例如，一个孤电子作轨道运动，如果对这一轨道运动作等时距抽样，在想象中形成一个“电子系综”，那么这个系综中的诸电子将在同一轨道上运行，这一点刚好又是“测不准关系”所排斥的。

玻恩告诉我们：对于电子束来说，波函数给出一个电子束中的诸电子的状态的“统计分布”，从而给出了其中的单个电子的“概率分布”。氢原子中的电子是单个电子，因此，波函数给出了该电子的概率分布。在这里，玻恩混淆了“群电子”与“孤电子”。对于群电子，单个电子的概率分布乃是电子束的统计分布的观念映像，因此，波函数对“群电子”的物理意义实际上就是波函数对“电子束”的物理意义。而对于氢原子中的孤电子，没有电子束的统计分布，作为统计分布观念映像的概率分布也不存在了。因此，玻恩的“概率诠释”仅仅对“群电子”而言才是成功的，如果把它理解为对“孤电子”的诠释，则它是一个失败的诠释。

薛定谔的电磁诠释或许是唯一的以孤电子为对象的诠释，我们知道，这个诠释是失败的。

但是，如果以群电子为对象，换句话说，如果以电子束为对象，则薛定谔的电磁诠释至少和概率诠释是同样胜任的。

在薛定谔的波动力学中，电子的电荷与波函数的模方的乘积给出一个“电荷分布函数”，薛定谔把这个函数理解为单个电子的“电荷的分布函数”。这样，单个电子的电荷就在空间像云雾一样连续分布。不幸的是，在描写氢原子的薛定谔方程中，表示电子与原子核的相互作用的项却是点电荷的库仑势。于是，矛盾出现了：像云雾一样连续分布的单个电子怎么会有点电荷的库仑势呢？这一矛盾像梦魇一样困扰着他的“电磁诠释”。但是如果把这个电荷分布函数理解为电子束的电荷的分布函数，困难就消失了：单个电子的电荷是点电荷，因此有点电荷的库仑势；大量电子的电荷则在空间连续分布。这就像云雾一样，单个的雾珠是点状的，而大量雾珠则是在空间连续分布的。

又例如，薛定谔把单个电子理解为一个波包，可是洛仑兹已经指出：在量子力学中，某一时刻形成的局限在一个小体积内的波包，会由于色散效应而随着时间进程而弥漫开来，从而不再是波包。洛仑兹由此得出结论：“由于这种不可避免的弥漫现象，波包并不宜于代表那些其单独存在应当是相当持久的东西。”这是薛定谔的电磁诠释的另一个令人沮丧的困难。可是只要把单个电子换成电子束，这个困难也悄然消失：在量子力学中，某一时刻形成的局限在一个小体积内的电子束，会由于色散效应而随着时间进程而弥漫开来。一言以蔽之，电子束中的诸电子不可能在同一轨道上运行，甚至也不可能全部集中在很接近的许多轨道上运行。这一结论，正是波包不可避免的弥漫现象的真正含义。

总之，无论是薛定谔的“电磁诠释”还是玻恩的“概率诠释”，只要理解为对“群电子”的诠释，则它们都是成功的诠释；反之，如果理解为对“孤电子”的诠释，则它们都是失败的诠释。

进一步的考察可以得出结论：现存的对量子力学的各种各样诠释充其量只是对“群电子”的诠释。但是我们不要忘记，薛定谔正是从波函数对氢原子中的单个电子的描述得到薛定谔方程的，因此波函数对“孤电子”肯定有意义。但怎样理解波函数对“孤电子”的意义，至今还是一个没有解决甚至没有提出的问题。

如果量子物理学家们弄清了“概率”这一用语的含义，哪怕是对它有赖欣巴赫那样的不确切的认识，他们就能得出结论：对于原子中的单个电子来说，波函数与“概率”扯不上关系，这样一来，他们就不会满足于“波函数的概率诠释”了。

测不准关系

由于把概率分布理解为一种现实的分布，波恩的“波函数的概率诠释”就被弄得面目全非，所有的微观现象全被误解，“测不准关系”就是一个典型的例子。

如果我们不曾忘记“概率分布是统计分布的观念映像；而统计分布则是概率分布的现实原型”，则测不准关系的本来含义是不难弄清楚的。

首先考察一个特例：根据量子力学的“形式体系”及波恩对波函数的概率诠释，可以得出如下命题：

“如果一个电子的动量取某值的概率为 1，则它在全空间任何一点出现的概率密度相等。”

这里的“一个电子的动量取某值的概率为 1”乃是单个电子的动量的概率分布，它是一个观念上的分布，其现实原型是如下统计分布：所观察的电子属于一个诸电子的动量一致的电子束。同样，“一个电子在全空间任何一点出现的概率密度相等”观念地映射如下统计分布：该电子束的诸电子在全空间均匀分布。因此上面的命题只不过是一个观念映像，其现实原型是如下命题：

“如果一个电子束诸电子的动量一致，则其诸电子的位置分布是均匀的。”

一般地说，测不准关系是指单个电子的位置的概率的分布范围与动量的概率的分布范围的乘积不能小于普朗克常量。按照“概率”这一用语的本来含义，这一关系是大量电子的位置分布与动量分布之间的一种关系，而且还是物理学中的一种常见的“交叉分散”关系。这种对测不准关系的理解，正是 1934 年波普尔提出的“量子力学的统计系综诠释”。按照这种诠释，测不准关系是电子束的一种性质，并不与经典物理学相冲突，特别是，电子的运动仍然是轨道运动。

但是，如果把概率分布误解为一种现实的分布，则单个电子不是粒子，而是一个由波函数描写的连续波场。于是，测不准关系表示：单个电子无论在位置空间和动量空间都会像云雾一样弥漫开来，这种弥漫的范围彼此制约，从而电子的运动不是轨道运动，而是云雾般的分布运动。

如果说“轨道运动”表现一幅“经典的粒子图景”，那么“云雾般的分布运动”就表现一幅“经典的波动图景”。哥本哈根学派的根本信念是电子的行为是“非经典的”，因此它虽然否定“电子的运动是轨道运动”，却并没有因此而确认“电子的运动是云雾般的分布运动”。那么，他们到底怎样理解测不准关系呢？

在《伯克利物理学教程》的《量子物理学》一书中，作者对这一问题作了如下回答：

“对测不准关系常常作如下解释：动力学变量诸如位置、动量等必须从操作上来定义，即根据它们的实际步骤来定义。如果我们分析微观物理学中的实际测量步骤，其结果是测量总要扰动体系；在体系与测量仪器之间存在一个特有的不可避免的相互作用。由于这种干扰，如果我们试图非常精确地测定一个粒子的位置，则在测量后它的动量将非常不确定，如果我们试图非常精确地测量它的动量，则在测量后它的位置将非常不确定，如果我们试图同时测定粒子的位置与动量，则这两个测量的结果的精确度将服从测不准关系。

“按照这种解释，一个电子沿着一条确定的轨道运动。但作了如下改进，通过将测不准关系强加在决定轨道的初始条件上，从而在电子沿哪一条轨道运动上引进不确定性。但是实验事实表明：我们必须以深奥得多的方式修改我们的概念：测不准关系给出了一些限度，超过了这些限度，像位置与动量这样的经典概念就不能应用。经典动力学的变量是时间的确定函数并且在原则上能以任意的精确度知道的，用这样的经典动力学变量描述的‘经典动力学体系’是想象中的虚构体，它在实际世界里并不存在。”

（为了上下文一致，上面的引文作了一点词句上的修改。）

量子物理学家们对测不准关系的看法并不一致，哥本哈根学派的领袖波尔与海森堡就有很

大分歧，上面的两种说法都是各种量子力学教程中常见的。量子力学处于这种现状的原因是极为复杂的，仅仅把这种现状描写下来就得写一本书，我们把这一有趣的工作留给未来的历史学家们。

哥本哈根迷误

按照波函数的概率诠释，波函数所给出的“概率分布”也是一种“观念的反映”，其“现实原型”则是大量电子所组成的电子“系综”的“统计分布”。可是，在某些场合，例如在氢原子中，波函数描写的对象却是单个电子。哥本哈根学派因此而误解了“概率”这一用语的含义，把“概率分布”误解为一种“现实的分布”，这种误解无异于说：单独掷一次硬币，该硬币出现半个正面和半个反面。由于波函数仅出现在微观世界，因此哥本哈根学派把这种误解的范围仅限于微观世界，对于宏观世界，人们还保持着对概率的通常的理解，我把这种独特而又有限的对概率的误解，称为“哥本哈根迷误”。由于仅限于微观世界，“哥本哈根迷误”并不显得过分荒谬。

你或许会说，只有傻瓜才会得出“单独掷一次硬币，该硬币会出现半个正面和半个反面”的结论！可哥本哈根学派的物理学家们，一个个都聪明绝顶，怎么说那样的蠢话呢？

不！“概率”是一个颇为挠头的用语，其含义十分曲折，聪明绝顶的人也难免在这里误入歧途！再说，像“单独掷一次硬币，该硬币会出现半个正面和半个反面”这样离奇的事情，谁要说会出现在宏观世界，那自然是蠢话，可是谁要说会出现在微观世界，那就是“新颖观念”了。

然而，人们真的能把世界分成平淡的宏观世界和离奇的微观世界两部分吗，“薛定谔猫”这一理想实验对这一问题给予了否定的回答。薛定谔猫的推理过程可表述如下：

第一，根据理想实验给出的条件，宏观事件“猫的死亡”与微观事件“原子衰变”相互等价（要么都发生，要么都不发生）。

第二，原子衰变是一个微观事件。按照哥本哈根诠释，对于微观事件，概率分布是一种现实的分布。因此，对于原子衰变，（1/2, 1/2）这一概率分布意味着该原子有一半衰变了，而另一半却没有衰变。

第三，根据概率论，相互等价事件具有同一概率。既然对于“原子衰变”，概率分布（1/2, 1/2）是一种现实的分布，那么，对于与它等价的事件“猫的死亡”，概率分布（1/2, 1/2）也是一种现实的分布。

第四，对于事件“猫的死亡”，“概率分布（1/2, 1/2）是一种现实的分布”意味着“半个活猫与半个死猫混合在一起”。

第五，于是，按照哥本哈根诠释，薛定谔猫在给定时刻的状态是“半个活猫与半个死猫混合在一起”。

总之，“薛定谔猫”这一理想实验沟通了原子衰变这一微观事件与猫的死亡这一宏观事件，使得“哥本哈根迷误”在宏观世界显现出来：当猫被置于箱中一小时以后，猫的状态的概率分布是：“猫死去的概率是 1/2，活着的概率也是 1/2。”这一概率分布的本来含义是：如果有大量的薛定谔猫，在同一时刻被置于有相同的装置的钢箱中，则过了一小时以后，大约有一半猫死

去，一半猫还活着。由于哥本哈根迷误，人们不得不把这一概率分布理解为“一小时以后，箱中的猫是半个死猫与半个活猫的混合物”。这样，薛定谔就揭示了量子力学的“哥本哈根诠释”的荒谬绝伦。

现在我们知道薛定谔猫为什么会如此招人憎恨了：二十世纪物理学的特殊的发展进程，已经使这一领域里的人们深信微观世界是“匪夷所思”的，在那里，层出不穷地出现违背任何逻辑规律的奇迹，谁要对那里发生的事情问一个“为什么”，那只能说明他深受经典物理学的传统观念的束缚。在这种形势下，微观世界成了量子物理学家的领袖们丰富的想象力纵横驰骋的“奇迹王国”。

例如，对于微观世界我可以说：电子既是粒子又是波，或者既不是粒子又不是波；对于微观世界我可以说：在电子的双缝衍射实验中，当一个电子越过一个有两条缝的墙壁时，它会同时通过两条缝越过，或者，它既不通过这条缝也不通过那条缝，但还是越过了墙壁；对于微观世界我可以说：一个原子一半衰变了而另一半却没有衰变。总之，微观世界的规律就是这样不可思议，如果没有超常的智力就无法理解。在量子物理学的领袖们的绝对权威下，不言而喻，所有的量子物理学家甚至所有量子物理学的初学者都有了超常的智力。

但是，即使是对于量子物理学的领袖们来说，不可思议的事情只许发生在看不见的微观世界，而不许发生在看得见的宏观世界，这里的事情你太熟悉了，上帝赋予我的超凡脱俗的想象力再也没有用武之地。

不幸的是，薛定谔猫这一理想实验却揭示一个事实：即使你有天大的本领，也不能把上面那些美妙的结论禁锢在微观世界里。你说一个原子一半衰变了而另一半却没有衰变，这一理想实验就从它引出“半只活猫与半只死猫混合在一起”的结论，你说电子的状态取决于测量，这一理想实验就从它引出“猫的生与死取决于人眼的一瞥”的结论。这简直是罪大恶极，难怪霍金忍不住要去拿他的枪了。

然而，对薛定谔猫的上述理解要求弄清楚：

第一，概率分布是一种观念上的分布；

第二，哥本哈根学派把概率分布误解为一种现实的分布。

因此对于薛定谔猫，虽然像霍金那样大学者极为震怒，但绝大多数量子物理学家们却由于没有弄清楚上面两个事实，并未感到特别的不安。

两个幽灵

我们看到，薛定谔猫处于“半个活猫半个死猫”的状态，正如硬币出现“半个正面半个反面”的状态一样，纯属子虚，只不过是一种不着边际的幻想，它来自哥本哈根迷误，即来自对“概率”的误解而引起的概念混淆。因此，不可能有一种数学表达式来表现这种状态，更不可能有一种实验的仪器能实现这种状态。不幸的是，在量子力学的发展进程中，这两个幽灵都出现了：人们认为，这种不可思议的状态被某种数学表达式所描述，甚至还在某些最新的实验事实中出现。

关于这两种幽灵，我们将另文考察。

Detestable Schrodinger's Cat

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Abstract: Throwing a coin conveniently, when the coin has fixed, the probability distribution of its state is that: the probability to appear its front side is 1/2, and that to appear its reverse side is also 1/2. The meaning of this probability distribution is originally that: Throwing the coin repeatedly, the number of times to appear its front side will approach to one half, and that to appear its reverse side approach to one half. If some one comprehends this probability distribution as that the very coin appears such a state, half of its surface is front and the other half is reverse, then he has misunderstood the meaning of probability.

According to the probability interpretation for wave function, the objective that a wave function described is originally an electron ensemble, but it is regarded as a single electron in the opinion of Copenhagen school. As a result, the above misunderstand is appeared. Wave function only exists in micro world, so that this misunderstand is only limited in micro world. In the macro world, the comprehending for probability by Copenhagen school is still normal. Such a distinctive and restricted misunderstand for probability is called "Copenhagen puzzle" by me. Because limited in micro world, "Copenhagen puzzle" appears not excessive absurd.

Unfortunately, the ideal experiment "Schrodinger's cat" makes "Copenhagen puzzle" turn up in macro world. At the moment that the cat is put in the box an hour later on, the probability distribution of the cat's state is that: the probability that the cat has died is 1/2, that the cat still live is 1/2. The meaning of this probability distribution is originally that: If there is a lot of "Schrodinger's cat", those are put in a box respectively at the same time. Then, among them about half number of cats have died and half still live in an hour after. Due to Copenhagen puzzle, this probability distribution is misunderstood as that a single Schrodinger's cat is a mixture composed of half died cat and live cat. As such, Schrodinger has revealed utterly absurd in Copenhagen interpretation.

Key words: Schrodinger's cat; uncertainty; probability distribution; wave function; Copenhagen puzzle

双缝衍射实验的奥秘

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内容提要：双缝衍射实验之所以令人双缝困惑，是因为根据似乎不容置疑的推理，人们曾期望在两条缝同时打开的条件下的衍射图形应该是在两条缝轮流打开的条件下得到的两个衍射图形的迭加。但实验结果却恰好相反。为了说明这一实验事实，前人创建了各种量子力学的诠释，其中包括被称为正统诠释的“哥本哈根诠释”。费曼把这一诠释的基本出发点归结为：必须放弃“每一个达到屏幕的电子不是通过第一条缝就是通过第二条缝”这一前提，从而得出“电子的运动不是轨道运动”的结论。

在费曼的推理中，默认了如下假设：在双缝衍射过程中，单个电子通过某一条缝落在屏上某处的概率，与另一条缝的启闭无关。或者说：“在两条缝同时打开的条件下单个电子落在屏上某处的概率，是在两条缝轮流打开的条件下该电子落在该处的两个概率之和。”与静电场的迭加原理比较，这个假设可以表成“概率遵循迭加原理”，我们称它为“概率的迭加假设”。

如果放弃“概率的迭加假设”，则我们可以保留“电子的运动是轨道运动”这一前提，从而双缝衍射实验不再有神秘之处，但下面两个命题还有待证明：第一，在双缝衍射过程中，单个电子通过某一条缝落在屏幕上某处的概率，确实与另一条缝的启闭有关。第二，电子的运动确实是轨道运动。
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关键词：双缝衍射实验；费曼；全概率公式；布尔代数；迭加原理

1. 引言

著名的美国物理学家费曼曾说：在双缝衍射现象中，“有着量子力学的核心，实际上，它包括了这个理论的唯一的奥秘。”

费曼是从一个特殊的角度理解双缝衍射实验的。在这里，我们将重新考察双缝衍射实验和费曼对它的特殊理解。首先，我们将考察前人为了说明双缝衍射实验而提出的几种量子力学的诠释。

2. 哥本哈根诠释

在《费曼物理学讲义 III》一书的第一章中，费曼以“量子行为”为标题，详细考察了电子的双缝衍射实验的这一“奥秘”：如果电子枪发出一束电子通过两条缝落在后面的屏幕上，则一方面落在屏幕上的电子呈现出像子弹一样的颗粒性，另一方面屏幕上的电子的数目分布呈现出像水波一样的干涉现象。电子的这种行为表明如下命题不成立：

A 在两条缝同时打开的条件下的衍射图形将是在两条缝轮流打开的条件下得到的两个衍射图形的迭加。

而这种实验结果是“极其神秘”的，而且“你考虑的越多，就越会感到神秘。”费曼还说：

人们曾经设想单个电子以各种复杂方式绕行通过缝来解释这种行为，但都不成功。最后人们才认识到，双缝衍射实验否定了如下前提：

B　每一个达到屏幕的电子不是通过第一条缝就是通过第二条缝。

在《费曼物理学讲义 III》一书中，未曾详细表述如何从命题 B 导出命题 A。下面，我按照自己的理解，把这一推导过程表述如下：

第一步：按照命题 B，如果在电子的双缝衍射实验中同时打开两条缝，让一束电子通过这两条缝到达一个屏幕，则一个到达屏幕上的电子必须而且仅仅通过某一条缝。因此，如果用符号 e 表示一个到达屏幕的电子，E 表示“e 通过第一条缝”而 F 表示“e 通过第二条缝”，则有：

$$E + F = U(\text{必然事件}), \qquad E \cdot F = \varnothing\ (\text{不可能事件})。 \tag{1}$$

第二步，用Ω表示屏上的一个小区域，X表示“e落在Ω上”，则 E • X 表示“e通过第一条缝落在Ω上”；而 F • X 表示“e通过第二条缝落在Ω上”。根据事件运算的布尔代数规则，从(1)式可得出：

$$E \cdot X + F \cdot X = X, \qquad (E \cdot X) \cdot (F \cdot X) = \varnothing。 \tag{2}$$

第三步，根据概率的频率定义，从上述公式可得出：

$$\Pr(X) = \Pr(E \cdot X) + \Pr(F \cdot X)。 \tag{3}$$

这是概率的加法公式的一种形式。

第四步，根据概率的乘法公式，有

$$\Pr(E \cdot X) = \Pr(E) \cdot \Pr(X|E);\quad \Pr(F \cdot X) = \Pr(F) \cdot \Pr(X|F)。 \tag{4}$$

应用(4)式，(3)式表成

$$\Pr(X) = \Pr(E) \cdot \Pr(X|E) + \Pr(F) \cdot \Pr(X|F)。 \tag{5}$$

这是概率论中的“全概率公式”。

如果只打开第一条缝，事件“e落在Ω上”的概率为 Pr(X|E)；如果只打开第二条缝，该事件的概率为 Pr(X|F)；如果两条缝都打开，该事件的概率为 Pr(X)。按照全概率公式，Pr(X) 是 Pr(X|E) 和 Pr(X|F) 按照 Pr(E) 与 Pr(F) 的比例相加，特别是当 Pr(E) = Pr(F) = 1/2 时，Pr(X) 是 Pr(X|E) 和 Pr(X|F) 的算术平均值。考虑到Ω是屏幕上的任意区域，立刻得出被双缝衍射实验否定了命题A。于是费曼得出结论：双缝衍射实验表明，我们必须放弃命题B。

从数学的角度来看，命题 A 是(5)式的结论，而(5)式则是从(1)式出发，经过(2)式、(3)式和(4)式一步步导出的。我们看到，为了摆脱命题 A 与实验事实之间的矛盾，费曼的思路是：否定命题 B，从而否定了(1)式，这样就得不到命题 A。

如果电子的运动是轨道运动，则命题 B 肯定成立，因此费曼实际上断言：“电子的运动不是轨道运动。”这正是“哥本哈根诠释”的基本观点。在这张意义下，费曼提出的诠释属于量子力学的“哥本哈根诠释”。

3. 三种鲜为人知的诠释

同样为了摆脱命题 A 与实验事实之间的矛盾，有人得出了其它的量子力学的诠释，举例如下：

有人认为，命题演算中的“分配律”

$$(E+F)\cdot X = E\cdot X + F\cdot X$$

在这里不再适用，因此(1)式虽然成立，但从(1)式得不到(2)式，从而也得不到命题 A。建立在这种看法上的量子力学诠释称为“非分配逻辑诠释”，它是所谓“量子逻辑诠释”中的一种。

“哥本哈根诠释”与“非分配逻辑诠释”都确认全概率公式从而概率论不适用于微观过程，前者把这一前提追溯到经典概念，而后者则把它追溯到经典逻辑。

还有一种诠释不涉及经典概念与经典逻辑，仅仅否定概率论本身。例如，法国物理学家吉·洛查克继承了德布洛意的观点，认为概率论仅适用于“隐变量”，但它不适用于计算测量结果的平均值。因此，洛查克确认(1)式与(2)式，但否定(3)式，从而也得不到命题 A。

以建立“量子概率诠释”著称的 L·阿卡迪提出如下论点：根据概率的频率定义，(1)式、(2)式与(3)式适用于任何过程，但(4)式，即概率的乘法公式不适用于微观过程，因此还是得不到命题 A。阿卡迪把概率的乘法公式称为“贝叶斯公理”，并断言：“量子力学中的一切佯谬都是由于不适当地应用这一公理引起的。”

上面我们提到的四种诠释（哥本哈根诠释、非分配逻辑诠释、洛查克的隐变量诠释以及阿卡迪的“量子概率诠释”）的存在表明：在得到命题 A 时，人们用了一个自以为是天经地义的前提，而它实际上却并不适用于微观过程。但对于究竟是哪一个前提不适用于微观过程的问题，人们的意见不一致。

我们知道，哥本哈根诠释现在是量子力学的“正统诠释”，而其他三种诠释却鲜为人知，为什么会这样呢？我的意见如下。

用“非分配逻辑”来说明量子现象也像用“三值逻辑”来说明量子现象一样，有两个令人沮丧的困难：第一，我们必须借助于“布尔逻辑”来研究“非布尔逻辑”。第二，量子力学理论的数学工具是根据“布尔逻辑”展开的，如果要在“非布尔逻辑”的框架下，建立一种量子力学诠释，那么，这种诠释不仅要重新建立逻辑原理与物理学原理，而且还得重新建立数学原理，这是一个令人望而生畏的任务。

其实，从(1)式导出(2)式仅用到概率论中的“事件运算”的布尔代数规律，我们满可以在微观物理学领域里保留“命题演算”中的分配律而放弃“事件运算”的分配律，这样，放弃(2)式所面临的阻力就小得多了。或许，人们并不喜欢这种做法：从量子论与相对论建立以来，不少人醉心于“根本推翻”前人的“传统观念”，他们会认为这样的小打小闹“不够气魄”。此外，还有一个问题：在保留逻辑运算的布尔代数规律的前提下，我们能修改事件运算的规律吗？

布尔代数应用范围很广，除了命题演算和事件运算以外，还有其他领域，例如电路运算。我想，如果我们遇到某种复杂的电路，布尔代数的电路运算法则不再适用，我想没有人会担心“布尔逻辑”因此而被“非布尔逻辑”所取代，从而全部数学将面临崩溃。同样，即使在微观物理学领域，事件运算的规律有所改变，我们也不必担心命题演算的规律会跟着改变。

上面，我们仅指出放弃(2)式并不意味着放弃“经典逻辑”，并不认为在微观物理学领域里必须放弃(2)式。

洛查克的隐变量诠释断言概率论对于隐变量理论是适用的，只是不适用于被测量的“可观

察量”。但我们以后将看到，微观的事件空间是“非布尔”的，在其中某些布尔代数的规则确实不成立。如果在一个隐变量理论中，概率论对于隐变量理论是适用的，则全部事件运算的布尔代数规则也适用于隐变量，从而在通常的情况下，这个隐变量理论得出关于可观察量的事件运算也会满足布尔代数的规则。要从它得出“非布尔”的事件空间，即使可能，也将是极为复杂而生硬的。

阿卡迪断言概率论的乘法公式不适用于微观过程，这是一种极为独特的论点，似乎至今还没有得到其它人的支持。乘法公式表现概率论的一个基本规律，即使在微观世界也有时用到，要放弃这一规律将会遇到各种困难。但对于概率论，人们只确认频率定义肯定适用于微观过程。按照当前的概率论教程，乘法公式却不是从频率定义得出的必然结论，因此我们也不能断然拒绝阿卡迪的诠释。下面我们将看到，如果适当修改频率定义，就能把乘法公式作为一个定理从频率定义导出，从而否定阿卡迪的诠释。

4. 概率的频率定义与乘法公式

按照现在的概率论教程，频率定义的对象是“无条件概率”，而“条件概率”则通过乘法公式来定义。如果修改频率定义使它成为“条件概率”的定义，则会立刻否定了阿卡迪的诠释。

经过修改的频率定义可表述如下：

定义 1： 考虑如下过程：某一试验不断重复，其中在条件S下重复了N 次，而在这N 次重复实验的结果中，有N_E个具有性质E。那么，当时N无限增大时，比值N_E/N 的极限就是在条件S下出现具有性质E的结果的概率，记作 $\Pr(E|S)$。即，

$$\Pr(E|S) = \lim_{N\to\infty} \frac{N_E}{N}。$$

那么，什么是“无条件概率”呢？如果对于所考察的问题，所涉及的事件都是在一个共同的条件R条件下进行的，从而对于该问题，R是一个“先决条件”，则对于出现在该问题中的某一概率表达式来说，符号R 可以省去，即 $\Pr(A|R\cdot B)$ 可略写作 $\Pr(A|B)$，$\Pr(A|R)$ 可略写作 $\Pr(A)$。在这里，概率表达式 $\Pr(A)$ 就表示“无条件概率”了。按照这种规定，一切概率都是条件概率，所谓“无条件概率”只不过是略去了条件符号的条件概率。

原来的频率定义与乘法公式之间的关系是极为微妙的。从这种频率定义出发，可以作一些定性的叙述，使初学者相信乘法公式是合理的，甚至还能得出一些结论，它们是应用乘法公式的例子，但就是不能从原来的频率定义推导出乘法公式。因此，人们只好把这一公式作为“条件概率”的定义来处理。而新的频率定义却能推导出概率的乘法公式。下面我们给出这一推导。

如果仍然用原来的概率的频率定义的用语，那么，在新的频率定义中，不断重复的试验的某些结果所成之集，称为一个“事件”。一个条件等同于一个事件，它是在这一条件下进行的重复试验所得到的全部试验结果所成之集。同样，一种性质也等同于一个事件，它是具有这一性质的全部试验结果所成之集。

设某一试验在 S 条件下重复了 N 次，在这 N 次试验的结果中，有 N_E 个具有性质 E，有 N_{EF} 个具有性质 $E\cdot F$。那么，概率的频率定义给出：

$$\Pr(E|S) = \lim_{N\to\infty}\frac{N_E}{N}, \qquad \Pr(E\cdot F|S) = \lim_{N\to\infty}\frac{N_{EF}}{N}。$$

按照惯例，对应于事件 E 的条件或性质也记作 E。根据事件、性质与条件的上述同一性，具有性质 E 的结果属于事件 E，而在 S 条件下进行的试验的结果则属于事件 S。因此，如果一个结果是在 S 条件得到的，并且具有性质 E，则它既属于事件 S 又属于事件 E，从而属于积事件 E·S。对于我们所考察的过程，有这种结果的试验重复了 N_E 次，因此积事件 E·S 有 N_E 个元素。另一方面，积事件 E·S 可以看作是在 E·S 条件下进行的试验的结果。我们由此得出结论：

I，对于给定的过程，恰好有 N_E 次重复试验是在 E·S 条件下进行的。

同样可以得到：

II，对于给定的过程，在 E·S 条件下进行的 N_E 次重复试验中，恰好有 N_{EF} 次的结果具有性质 F。

根据定义 1，从 I 与 II 我们可得到

$$\Pr(F|E\cdot S) = \lim_{N_E\to\infty}\frac{N_{EF}}{N_E}。$$

另一方面，根据极限理论，有

$$\lim_{N\to\infty}\frac{N_{EF}}{N} = \lim_{N\to\infty}\frac{N_E}{N}\cdot\lim_{N_E\to\infty}\frac{N_{EF}}{N_E}。$$

上面诸式给出

$$\Pr(E\cdot F|S) = \Pr(E|S)\cdot\Pr(F|E\cdot S)。$$

这是一个从定义 1 导出的公式。

如果把上式中的 S 作为先决条件，从而它可以在每一个概率表达式中省略，则该式略写成

$$\Pr(E\cdot F) = \Pr(E)\cdot\Pr(F|E)。 \qquad (6)$$

这就是概率的乘法公式。它不再是条件概率 Pr(F|E) 的定义，也不是一个公理，而是从频率定义导出的一个定理了。

阿卡迪的论点表明：把(6)式看作一个公理或看作条件概率的定义有可能使人怀疑其普遍有效性。而当我们从概率的频率定义导出(6)式时，这种可能性就不再存在了。

5. 对全概率公式的另一种推导

我们看到，非分配逻辑诠释、洛查克的隐变量诠释以及阿卡迪的“量子概率诠释”都有明显的弱点。下面，我们对命题 A 的给出另一种推导，从根本上排除这三种诠释。

在电子的双缝衍射实验中，分别考察如下三个过程。

第一，设电子源平稳地发射着电子，在同时打开两条缝的条件下经历时间T，有N个电子落在屏幕上。如果命题B成立，则过程中通过第一条缝的电子数N_1与通过第二条缝的电子数N_2是确定的，而且通过第一条缝落在Ω上的电子数n_1与通过第二条缝落在Ω上的电子数n_2也是确定的，而落在Ω上的电子总数则是n_1+n_2。设e是落在屏幕上的N个电子之一，则根据概率的频率定义，当N足够大时，e落在Ω上的概率是

$$\Pr(X) = \frac{n_1 + n_2}{N};$$

此外，e 通过第一条缝的概率和通过第二条缝的概率可分别表成

$$\Pr(E) = \frac{N_1}{N}, \qquad \Pr(F) = \frac{N_2}{N}。$$

第二，假定其它条件保持不变，仅关闭第二条缝，同样经历时间T，则还是会有N_1 个电子通过第一条缝落在屏幕上，其中还是有n_1 个电子落在Ω上。在这一过程中，已知 e肯定通过第一条缝，因此它落在Ω上的概率为

$$\Pr(X|E) = \frac{n_1}{N_1}。$$

第三，同样，如果仅关闭第一条缝，则e落在Ω上的概率为

$$\Pr(X|F) = \frac{n_2}{N_2}。$$

根据显然的数字关系

$$\frac{n_1 + n_2}{N} = \frac{N_1}{N} \cdot \frac{n_1}{N_1} + \frac{N_2}{N} \cdot \frac{n_2}{N_2},$$

我们重新得到(5)式，从而重新得到命题 A。上面的推导没有用到命题演算的分配律、概率的加法公式与乘法公式，从而完全排除了非分配逻辑诠释、德布洛意或洛查克的隐变量诠释以及阿卡迪的“量子概率诠释”。

排除了这三个诠释，我们从命题 A 的推导似乎只能引出哥本哈根诠释。但是，还有一个隐蔽的前提在这里被忽略了。

6. 迭加原理

在小学的算术中，有一种类型的问题称为“工程问题”。例如：某一个工程，甲单干 15 天能完成，乙单干 12 天能完成，丙单干 10 天能完成，问甲乙丙三人合干几日能完成。这道题的标准答案是这样的：甲一天能完成该工程的 1/15, 乙一天能完成 1/12, 丙一天能完成 1/10, 于是甲乙丙三人合干一天能完成该工程的 1/15 + 1/12 + 1/10 = 1/4。因此，该工程如果由甲乙丙三人合干，则 4 天能完成。

这个标准答案立足于如下前提：

C 当甲乙丙三人合干时，三个人一天完成的总工作量是他们三人各自单干时一天完成的工作量之和。

这个前提是不是一定成立呢？诚然，当甲乙丙三人合干时，三个人一天完成的工作量总是这三个人干的而不是其它什么人干的，因此，如果甲一天完成的工作量是a，乙一天完成的工作量是b，丙一天完成的工作量是c，则三人一天完成的工作量肯定是a + b + c。但是，这里说的甲一天的工作量a是指他在与其它两人合干时的工作量，而不是指他单干时一天的工作量。因此，上述的标准答案有一个默认的前提：

D 当甲乙丙三人合干时，每个人一天完成的工作量与他们单干时的工作量时是一样的。

这是一个合乎常情的前提，却并不是一个天经地义的前提。当三个人合干时，可能由

于合理分工，效率有所提高；也可能由于有人偷奸取巧，效率反而降低了。甚至可能出现如下情况：这在这三个人中有“一个干的，一个看的，一个捣乱的。”那么效率更会大大降低。总之，当甲乙丙三人合干时，每个人一天完成的工作量与他们单干时的工作量有可能是不同的。因此，对于上述工程问题的标准答案，命题 D 乃是一个附加的假定，这个不起眼的假定在物理学上却有一个十分响亮的名称。

在静电学中有如下基本的实验事实：

E　设有两个点电荷，第一个点电荷单独存在时，观察点的电场强度为 $\mathbf{E}_1$，第二个点电荷单独存在时，观察点的电场强度为 $\mathbf{E}_2$，则两个点电荷同时存在时，观察点的电场强度为 $\mathbf{E}_1+\mathbf{E}_2$。

这一实验事实称为“静电场的迭加原理”，它是静电学中的一个基本原理。

对于某些物理量，类似的“迭加原理”并不成立。例如，根据静电场理论，静电场的能量密度 u 与电场强度 **E** 的自乘成正比，即存在常量 k，使得

$$u = k\mathbf{E}\cdot\mathbf{E}。$$

因此，对于上面考察的两个点电荷，第一个点电荷单独存在时，观察点的静电场的能量密度为 $u_1 = k\mathbf{E}_1\cdot\mathbf{E}_1$，第二个点电荷单独存在时，观察点的静电场的能量密度为 $u_2 = k\mathbf{E}_2\cdot\mathbf{E}_2$，而根据静电场的迭加原理，当两个点电荷同时存在时，观察点的电场强度为 $\mathbf{E}_1+\mathbf{E}_2$，因此观察点的静电场的能量密度为

$$u = k(\mathbf{E}_1+\mathbf{E}_2)\cdot(\mathbf{E}_1+\mathbf{E}_2) = u_1+u_2+u_{12}$$

这里，$u_{12} = k(\mathbf{E}_1\cdot\mathbf{E}_2+\mathbf{E}_2\cdot\mathbf{E}_1)$ 是一个“交叉项”，表示一种“相互作用能”，它的存在使得静电场的能量不遵循迭加原理：当两个点电荷同时存在时观察点的能量密度，不等于两个点电荷各自单独存在时观察点的两个能量密度之和。

比较命题 C 与命题 E，我们看到某种共同之处，既然命题 E 表示“静电场的强度遵循迭加原理”，命题 C 似乎就该表示“工作量遵循迭加原理”了。这个用语是否合适，我们不在这里考察，但有一点可以肯定，命题 C 这个前提未必成立，从而默认这一前提乃是人们的疏忽。作为一道小学算术题，这种疏忽是无足轻重的，但在物理学中同样的疏忽却让人们付出了高昂的代价。

7. 概率的迭加假设

现在我们回到对命题 A 的第二种推导，这个推导也有一点小小的疏忽，其中有如下推理：

“设同时打开两条缝经历时间T，有n_1 个电子通过第一条缝并落在屏幕上的某一小区域Ω上。如果其它条件保持不变，仅关闭第二条缝，同样经历时间T，则还是会有n_1 个电子通过第一条缝落在屏幕上的Ω上。”

这一推理默认了如下前提：“在双缝衍射过程中，通过某一条缝落在Ω上的电子数，与另一条缝的启闭（打开还是关闭）无关。”

为了用数学的语言表述这一命题，首先要承认“打开第二条缝”还是“关闭第二条缝”是

不同是实验条件，在这两种实验条件下，“通过第一条缝落在Ω上的电子数”的含义不同，必须用不同的符号来表示。用n_1和m_1分别表示在打开和关闭第二条缝两种条件下通过第一条缝落在Ω上的电子数；用n_2和m_2分别表示在打开和关闭第一条缝两种条件下通过第二条缝落在Ω上的电子数，则上述推理默认的前提表成：

$$m_1 = n_1, \qquad m_2 = n_2, \tag{8}$$

现在，我们把第三节所考察的三个过程中的第二、第三两个过程合并成一个，即考虑如下两个过程：

过程 U：同时打开两条缝经历时间 T，有 N 个电子落在屏幕上。

过程 V：假定其它条件保持不变，先关闭第二条缝，经历时间 T，从而有 N_1 个电子达到屏幕上；再打开第二条缝，关闭第一条缝，再经历时间 T，从而有 N_2 个电子达到屏幕上。在整个过程中，也有 N 个电子落在屏幕上。

在这里，过程U是在“两条缝同时打开”的条件下进行的，过程V则是在“两条缝轮流打开”的条件下进行的，由于两个过程的实验条件不同，有关的概率有不同的含义，必须用符号来区分它们。如果还是用符号U和V表示这两个过程的条件，则按照概率论的通常写法，“在‘两条缝同时打开’的条件下的某一事件Y的概率”本应写成$Pr(Y|U)$，但为了方便，我们把这个概率表达式改写成$Pr_U(Y)$。同样，“在‘两条缝轮流打开’的条件下的Y事件的概率”写成$Pr_V(Y)$。如果Y事件的概率与两条缝“同时打开”还是“轮流打开”无关，则仍写成$Pr(Y)$。

还是用e表示一个“落在屏幕上的电子”，E表示“e通过第一条缝”而F表示“e通过第二条缝”，X表示“e落在Ω上”，则根据概率的频率定义，当N足够大时，对于过程U，我们有：

$$Pr_U(X) = \frac{n_1 + n_2}{N};$$

$$Pr_U(X \cdot E) = \frac{n_1}{N}, \qquad Pr_U(X \cdot F) = \frac{n_2}{N}。$$

根据显然的数字关系

$$\frac{n_1 + n_2}{N} = \frac{n_1}{N} + \frac{n_2}{N},$$

我们有

$$Pr_U(X) = Pr_U(X \cdot E) + Pr_U(X \cdot F)。 \tag{9}$$

在过程V中，落在屏幕上的电子总数还是N。还是用m_1和m_2分别表示通过第一条缝落在Ω上的概率与通过第二条缝落在Ω上的电子数，则有：

$$Pr_V(X \cdot E) = \frac{m_1}{N}; \qquad Pr_V(X \cdot F) = \frac{m_2}{N}。$$

于是(8)式表成：

$$Pr_U(X \cdot E) = Pr_V(X \cdot E), \qquad Pr_U(X \cdot F) = Pr_V(X \cdot F), \tag{10}$$

(10)式表示：

F　在双缝衍射过程中，单个电子通过某一条缝落在屏上某处的概率，与另一条缝的启闭无关。

(9)式和(10)式给出

$$Pr_U(X) = Pr_V(X \cdot E) + Pr_V(X \cdot F)。 \quad (11)$$

(11)式表示：

G　在双缝衍射过程中，在两条缝同时打开的条件下单个电子落在屏上某处的概率是在两条缝轮流打开的条件下该电子落在该处的两个概率之和。

如果说命题 E 表示静电场遵循迭加原理，那么命题 G 就表示“概率遵循迭加原理”。但由于命题 G 并不是一个实验事实，我们不能称它为“概率的迭加原理”。尽管如此，命题 G 曾经给我们带来长期的困扰，我们不得不一再提到它，因此它总得有一个名称，下面我们称它为“概率的迭加假设”。

考虑到Ω可以是屏幕上的任意区域，从命题G可以得到命题A。但是在导出命题G时，不仅用到命题B，而且还用到命题F，因此我们从双缝衍射实验得出的结论就不再是“命题B不成立”，而是“命题B与命题F不能同时成立”。

如果说命题B与常识是一致的，放弃它会导致“不可思议”的结论。那么，命题F却并非如此，人们接受这个前提仅仅是由于疏忽。因此，与其放弃命题B倒不如放弃命题F。因此，我们倾向于认为命题F并不成立，即我们倾向于认为：“在双缝衍射过程中，单个电子e通过某一条缝落在Ω上的概率，与另一条缝的启闭有关。”换句话说，就是“概率不遵循迭加原理”。

回到第三节对命题 A 的推导，从其中的第一个过程，我们得到的(5)式是：

$$Pr_U(X) = Pr(E) \cdot Pr_U(X|E) + Pr(F) \cdot Pr_U(X|F)。 \quad (12)$$

这是概率论意义下的“全概率公式”。在两条缝同时打开的条件下，我们无法分辨一个落在Ω上的电子到底是通过第一条缝还是第二条缝，从而$Pr_U(X|E)$和$Pr_U(X|F)$是不能测量的。因此，(12)式根本不能与实验结果相比较，从而也就不可能与实验事实相矛盾。

再考虑另外两个过程，并且把 Pr_V 理解为“另一条缝关闭”的条件下的概率符号，相应地，把 Pr_U 理解为“另一条缝打开”的条件下的概率符号，则命题 G 表成

$$Pr_U(X) = Pr(E) \cdot Pr_V(X|E) + Pr(F) \cdot Pr_V(X|F)。 \quad (13)$$

从命题 B 只能导出(12)式，它是概率论意义下的全概率公式，而导出命题 A 的则是(13)式，它是“概率迭加假设”的另一种表达式。哥本哈根学派混淆了(12)式与(13)式，这才得出“从命题 B 可以导出命题 A”的结论。

8. 结束语

我们看到，如果我们认为：被双缝衍射实验所否定了前提，并不是“每一个达到屏幕的电子不是通过第一条缝就是通过第二条缝”，并不是“电子的运动不是轨道运动”。而是一个由于疏忽而默认的结论：“概率遵循迭加原理。”则双缝衍射实验实验结果并不神秘，而是再自然不过的。而且你考虑的越多，就越会感到它简直是不言而喻的。

尽管如此，下面两个命题还有待证明：

第一，在双缝衍射过程中，单个电子 e 通过某一条缝落在屏幕上某处的概率，与另一条缝的启闭有关。

第二，电子的运动确实是轨道运动。

Profound in Double Slit Diffraction Experiment

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Abstract: We are in a puzzle about the double slit diffraction experiments because that we once expected that the diffraction pattern under the condition that two slit open simultaneously, is the overlaying of two diffraction patterns under the condition that two slit open in turn, but the experimental fact gave an answer in the negative. To explain such facts, various quantum mechanics interpretations were advanced. Specially, Feynman asserted that it is necessary to abandon the promise that any an electron arrived at the screen either passing the first slit or passing the second slit, in other words, it is necessary to recognize that the electron's movement is not orbit movement. This result is the starting point of Copenhagen interpretation, which is regarded as the orthodox interpretation.

In the Feynman's reasoning, a hypothesis that "the probability of the event that an electron passes through a certain slit and arrives somewhere on the screen is independent of the condition whether or not the other slit is open" is tacitly approved. This hypothesis is able to express as following form: The probability of the event that an electron passes through a certain slit and arrives somewhere on the screen under the condition that two slit open simultaneously, equals the sum of two probabilities of the same event under the condition that two slit open in turn. Comparing with the superposition principle for static electric fields, this hypothesis can be expressed as that "the probabilities obey superposition principle", and is called "superposition hypothesis about probabilities" herein.

Abandoning this hypothesis, we can still remain the classical promise that an electron's movement is an orbit movement. However, there are two points have yet to be comfirmed: Firstly, the probability of the event that an electron passes through certain slit and arrives somewhere on the screen is sure dependent of the condition whether or not the other slit is open a single electron. Secondly, the movement of an electron is sure the orbit movement.

Key words: double slit diffraction experiment； Feynman; total probability formula; superposition principle; Boolean algebra

Ten most intelligent geniuses in science
十大科学才子

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摘要：
十大科学才子：
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2. 杰里·格尔德斯坦，35 岁，太空气象学家
3. 梅勒迪·斯瓦兹，37 岁，身体部件建造师
4. 大卫·汤普森，36 岁，北极厄尔尼诺现象发现者
5. 凯利·道甘，26 岁，蚓语者
6. 奥马尔·雅奇，41 岁，氢纳米建筑师
7. 陶哲轩，31 岁，数学家
8.萨拉·西格，35 岁，遥远行星搜寻者
9.埃里希·贾维斯，41 岁，鸟语翻译家
10.刘易斯·万安(Luis von Ahn)，27 岁，矩阵建造者
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关键词：尼玛·阿卡尼-哈米德；杰里·格尔德斯坦；梅勒迪·斯瓦兹；大卫·汤普森；凯利·道甘；奥马尔·雅奇；陶哲轩；萨拉·西格；埃里希·贾维斯；刘易斯·万安

引言

据《大众科学》14 日报道，美国着名的《大众科学》杂志评出了世界上前十位“科学才子”这是由数百位受人尊敬的科学家、大学系主任和科学杂志编辑经过 6 个月的精心筛选评出来的。《大众科学》杂志解释说，所谓“才气”的意思不是聪明，或者说至少不仅仅意味着聪明。说一个人有才气，就是说他有敏锐的洞察力、伟大的创造力和坚韧的毅力，有敢于避开现有知识以便形成自己独到见解的信心。这些“科学才子”也许在一领域中不是特别知名，也没有已经取得最突出成就，但是我们要寻找那些言行与众不同的人、那些年轻有为的人和那些不仅正在改变我们已知的事物还在改变我们知之甚少的事物的人。最后的获选者都是年轻人(平均年龄是 34 岁)，他们中的每个人都是刚刚被他们的领域之外的世界所了解。但是在他们的同代人中，这些优胜者持有的常常让人感觉非常激进的观点正逐渐赢得人们对他们无限的尊敬和赞美。就凭这些，他们就有资格跻身十佳“科学才子”。

十大科学才子：尼玛·阿卡尼-哈米德

1. 尼玛·阿卡尼-哈米德(Nima Arkani-Hamed)，
34 岁，第五维研究者

引力为何这样强大，它能牵引行星运转，然而它又是那样微弱，连一个简单的电冰箱磁铁就能抵御它的吸引？这一疑问长期困扰着物理学界：我们最权威的理论不能解释为什么引力比其他基本力(例如，电磁)还要微弱。尽管这是一个困难的问题，通常需要非常规的解决方法，但是尼玛·阿卡尼-哈米德和他的合作者却非常出色地提出了他们的假设。他们假定引力扩展到了我们居住的三维宇宙空间之外，进入非常巨大的多维空间中，从而削弱了它的能量。换句话说，我们的宇宙有漏洞。

经过一年的研究，发表了三篇论文后，围绕这一问题的崭新的研究领域开始萌芽。仅仅在他从伯克利的加州大学获得哲学博士学位一年后，阿卡尼-哈米德就已经变成了一个家喻户晓的名字(确切的说，是在理论家和粒子物理学者这个大家族中)。哈佛大学的理论物理学家霍华德·乔吉说：“对我来说，尼玛将要成为一颗耀眼明星是显而易见的事情，即使他还没毕业。现在他将他的同代人远远地抛在后面。提起这些有些令人难为情。”他曾试图劝说阿卡尼-哈米德来新英格兰的研究生院就读，但是没有成功。

阿卡尼-哈米德在 30 岁时终于从哈佛结束了他的全部学业，之后他顺利成为一名物理学教授。但是这次他孤注一掷进行研究的却不是多维空间，而是另外的宇宙(据他分析大约有 10500 个)。他和其他正在成长中的有独特见解的科学家猜想，我们的宇宙只是数不清的并列的宇宙中的一个。它们中的每一个都有自己的物理学规则和自然衡量。

他的关于多元宇宙存在的第一条证据虽然很间接，但它可能将于明年得到证明，此时日内瓦的物理学家将展示他们的大型强子对撞机----这个世界上最强大的粒子加速器的威力。如果阿卡尼-哈米德的设想是正确的，大型强子对撞机将显示出宇宙中被称作“分离超对称性”（split supersymmetry）的隐藏特征，分离超对称性理论是指宇宙中一半的粒子都有能被大型强子对撞机发现的配对的粒子存在。阿卡尼-哈米德说，如果它起作用了，大型强子对撞机发现了这些配对的粒子，“它将是证明多元宇宙存在的一个巨大线索。”

然而，这又预示着什么呢？还记得 500 多年前，当一个叫哥白尼的异教徒毅然打破宇宙中心说的情景吗？你要振作起来，为真理奋斗。如果阿卡尼-哈米德和他的支持者是正确的，我们现存的理论又将再一次被冲击。就像他所说的：“我们这个处于多元宇宙的的世界的重要性，将不比与我们宇宙中的所有物质相关的一个原子更强大。”

十大科学才子：杰里·格尔德斯坦

2. 杰里·格尔德斯坦，35 岁，太空气象学家

他的研究让我们知道了，为什么地球的等离子体磁层总是没有我们想象的那样稳定。当他还是布鲁克林大学的一名学生时，杰里·格尔德斯坦就获得了物理课上唯一的一个“B”，所以，他研究的东西并非每个头脑健全的大学生都能想到的——这也不足为奇了，他决定深入研究物理，用他的话说，“这是唯一一件能让我从头做到尾的事情。”他研究地球外层无形的磁屏蔽——磁层，虽然，科学家们知道，磁层的外层会受到了太阳风的冲击，太阳风是以每小时 100 万英里的速度从太阳射过来的微粒流，大多数科学家认为，磁层的内层，即等离子体是一个相对平静的带电气体层。

格尔德斯坦挑战的就是这些深奥的东西，通过 IMAGE 人造卫星收集到的资料，他证明，在最激烈的太阳风暴期间，那些人们原以为平静的等离子层几乎完全冲蚀进了外层，这会让宇航员们遭受强烈的电磁辐射，让国防和通信卫星的电路板起火，会让全球定位系统的指数出现 250 英尺的偏差。为了与他的新数据伏和，格尔德斯坦改造了地球与太阳相互作用的模型。在演示程序中，他显示了等离子体层是比我们想象中更加不稳定的一个自然环境。格尔德斯坦在西南研究学院的同事吉姆·布奇说：“如果没有格尔德斯坦，我们从现在起研究，要弄明白也还得 10 年的时间。”

十大科学才子：梅勒迪·斯瓦兹

3. 梅勒迪·斯瓦兹，37 岁，身体部件建造师

她正在证明的是人体内部一种神秘的液体流如何帮助我们长出器官。每次受伤都在提醒我们，我们的动脉中流淌着鲜血，但是，梅勒迪·斯瓦兹要证明的却是，组织的细胞间液体缓慢流动这鲜为人

知的事实的重要性。如果你幸运的话，在实验室里，你会见证这种流动是我们一直孜孜以求的，组织生长的关键所在。

在瑞士联邦理工学院洛桑分校，斯瓦兹指着她电脑显示器上的管道网问：“看到这些细小的，纺锤型的东西没有？这就是人体机能网络的开始。”斯瓦兹还是西北大学的一名生物工程师，屏幕上显示的机能网是她通过研究细胞间的液体流发现的第一个生物系统。以前，人们对循环系统促进器官生长知之甚少，生物工程师只能创建很少的，而且是简单的组织类型，如皮肤和心肌。但是，去年，斯瓦兹的人体细胞实验显示，在生长发育期间，细胞间液体流会重新分布叫做成形素的蛋白质，然后，这种信号细胞会创建支持组织生长的毛细管网。斯瓦兹是发现慢循环对于身体发育重要性的第一人。

斯瓦兹这项研究的动力是她的机械思维，学生期间，她的专业是工程学，而非生物学，甚至是今天，她仍她的发现比作“拆卸汽车，检查问题出在哪里。”她的研究可以说是尖端的，及其少有的，以致有时她遇到的困难竟是研究是否被准许，她的研究倾向于挑战权威理论。她的同事表示，这项困难显示了她的研究是多么的富有革命性，例如，她的发现暗示，在实验室创造可移植的器官将必须再造细胞间的循环。理解这种循环也有助于研究人员研发新的抗癌药物，既然癌细胞到身体的其他部位也需要细胞间的循环。马萨诸塞州理工学院的生物工程师林达·格里菲斯说：“她的研究显示，在身体循环中，细胞的微小变化。这将是一种基本的理念，这种现象将会持久存在。”

十大科学才子：大卫·汤普森

4. 大卫·汤普森，36 岁，北极厄尔尼诺现象发现者

他的北方气候模式这一重要发现将气候学推向了一个新的高度。二十几岁时，在大卫·汤普森还是华盛顿大学的一名研究生时，他帮助发现了一种现象从根本上改变了气候学家北极气候的理解模式。汤普森和他的指导老师大气学家约翰·华莱士最先确定了这种席卷北极的气候体系，他们称之为北极涛动，北极涛动改变了整个半球的气候模式，从克利夫兰的暴风雨到西班牙的降雨，再到东部沿海地区频繁的，可怕的风暴，这就是北极的厄尔尼诺现象。

从向北纬 55 度(大约与莫斯科、凯契根和阿拉斯加州平行) 旋起的逆时针大涡流能将它的负性期转变为阳性期，而且时隔不久就会频繁发生。负性期的环形风风速缓慢，风向极易改变，能将北极的冷空气吹进中纬度地区，阳性期的风很强劲，冷空气不会流散，但是，随着时间的推移，它的趋势渐渐明显，正循环与暖冬有关系，例如，20 世纪 80 年代和 90 年代的气候情况。

北极涛动的发现对很多气候研究领域都有最直接的影响，特别是研究气候改变的专家怀疑，尾气排放可能是造成北极涛动长时期保持阳性期的原因。南极洲部分地区变冷，汤普森(现为科罗拉多州立大学的一名教授)将注意力又转向了南方，而全球变暖怀疑论者也借此作为一种否定他理论的证据，事实上，南极洲也正在变暖，2002 年，汤普森和美国国家海洋大气局的苏珊·索罗蒙提出了一种温度失常的可能性解释——臭氧洞。他们发现，巨大的臭氧洞改变了南极洲风的模式，致使南极洲的表面温度降低，南极洲半岛除外，这里的冰川以惊人的速度在南冰洋中断裂。与汤普森的全球气候工作联系在一起的是人们对大气层上层重要性了解的缺乏。他说：“这里发生的一切就是最好的驳斥。”

十大科学才子：凯利·道甘

5. 凯利·道甘，26 岁，蚓语者

凯利·道甘是美国缅因州大学的一名在读博士生，她正在为自己的论文做准备，她的工作是要让地下的世界亮出来。道甘一边诱使一只蚯蚓挖通一个盛白明胶的桶，一边说：“我一向喜欢蚯蚓。”

这是一条 6 英寸长的沙虫，也就是俗称的蚯蚓，是由当地一家诱饵商店提供给她的，但这只蚯蚓并不愿意跟她配合，所以，道甘一边准备好她的录象设备一边刺它一下，她需要为完成的毕业论文提供良好的胶片。她打开了背后照明的灯光，那只蚯蚓在白明胶的表面扭来扭去，道甘调整了一下她的监视器，那只蚯蚓到处探来探去，道甘推了它一下，它就扭动一下，还是没有挖下去。这样反复折腾了几次后，我们的这个“小明星”终于同意跟她配合了，它突然表现出了解决一个人们不会期望一只无脊椎动物动物能够解决的问题的决心，把自己的头猛地扎向白明胶，迅速而突然地向下钻去。

道甘大部分时间是在这个寒冷的实验室里工作，她要挑战一个时间长达一个世纪的理论，这个理论正是达尔文所认可的，是有关蚯蚓是如何运动的理论。她的研究工作很快就让她成为了地下世界方面的权威，美国杜克大学的生物力学教授史蒂文·沃格尔就曾说过：“任何在她研究的领域里工作的人都是以查看她的论文或者给她写电子邮件开始工作的。”

蚯蚓是一种非常难以观察的蠕虫，而且生物学家从来就不能明确地说出它们是如何运动的，一向喜欢蚯蚓的达尔文是首先对这个问题进行严肃调查的科学家之一，他不相信当蚯蚓拱进土壤时土会在它周围松开，达尔文认为，当蚯蚓拱进土里时，它会吞掉前面的土，给自己开辟一条道路。达尔文的这一理论被人接受了 120 多年，但是后来，科学家提出了一个问题，那就是为什么它们如此热衷于挖地洞呢？与其它方法相比，比如走路、游泳以及飞行相比，吃出一条路来似乎是一种效率格外低的方法。

道甘认为，蚯蚓一定是在使用一种窍门帮助它们挖通泥土为自己开出一条路来，但研究这种现象的力学需要同等的工程学。她说：“我的学习背景仅限于生物学，我对我需要的物理学一点也不懂。”为了解决这一问题，她白天学习工程课程，晚上则搜寻有关蚯蚓挖土的窍门问题，最后她终于找到了一个被称为“光弹性压力分析”(photoelastic stress analysis) 的方法这种方法使用了一个用偏振光和照相滤光器精心设计的装置来测量物体所受的压力，她发现用海水和白明胶混合在一起具有海底沉淀物的物理特性，然后让其沉在一个容器底下。她把一条蚯蚓放上去，拍摄它挖地洞的情况。

通过研究蚯蚓周围的压力场，道甘发现蚯蚓其实是把嘴伸出来像一个木楔子一样撬开泥土，然后很从容地进入由于裂纹而产生的空隙。为了保持向前运动，它们就不停地撬开泥土产生缝隙。按工程学术语，这是一种裂纹扩展，而道甘的研究认为，这比蚯蚓吃掉泥土打通道路要少花费很多能量。

道甘的发现改变了科学家对整个地下生态系统的理解，生物学家意识到蛤蜊、海胆甚至生长的树根前端打出的洞穴都是在活的杠杆的作用下完成的。道甘下一步计划研究海岸地区更大规模的洞穴效应，在海岸地区，蚯蚓可以挖开上面四英寸后的泥土，寻找到被埋藏的营养物质而且能够搅拌像 DDT 这样的污染物。科学家自 1881 年开始就已经研究这种被称为“生物搅动 (bioturbation)”的现象了，当时，达尔文首次试图描述这种现象。

十大科学才子：奥马尔·雅奇

6. 奥马尔·雅奇，41 岁，氢纳米建筑师

他建造的“微型脚手架”将来有一天将用于你的气罐盛放氢。走出位于洛杉矶加利福尼亚大学的化学实验室，关上门，又回头看了看。他咧了咧嘴，说道：“对我所从事的职业来说，我有一个天大的秘密，那就是我害怕化学品。”

对一个化学家来说，这是一种不太可能的恐怖症，因为他的研究论文被列为该领域最有影响力的文章之一。但雅奇选择这个领域是因化学中活跃思维的一道道难题，而不是与爆炸物有关的因素。他

用自己曾发明的一种物质(看起来像婴儿奶粉)装满水壶，这种做法似乎很荒谬，但这个水壶却能比一间空屋子容纳更多的天然气，这可能会带来“氢汽车”可用的第一个燃料箱的发明。如果你将这种物质放大 10 亿倍，它们看起来就像巨大的脚手架。以前，材料科学家们见过类似的结构，但他们无法将其变成各种用于特殊目的的材料。南佛罗里达大学教授迈克·扎沃罗特科表示，按化学家的规范来设计这些结构是个梦想，雅奇正是将这一梦想变成现实的人。

为了建造这种结构，雅奇使用微型金属支架，因为它们能构成稳固的接合点，让他可以建成各种各样的模式。例如，他建造的构造结实的“蜂房”就能储存大量气体，气体分子会粘在横梁上，越聚越紧，在没有高压或低温的情况下将气体压缩。雅奇说：“我们人类都希望能控制周围的事物，我也不例外。”

正如在约旦他还是个小孩时，雅奇就希望独立管理自己的生活，每当父母要求检查成绩单时，他都感到很不愉快。在 16 岁时，他独自搬到美国开始了大学生活，从那时到现在，他一直致力于科学研究。他承认：“我发现在早上刮胡子或洗澡会影响工作。”在接下来的数年里，雅奇的献身有了回报，他的发明在现实世界中得到应用，比如俘获从烟窗排放的二氧化碳的过滤器。但对雅奇来说，这些还不算什么。他说：“我没准备要去解决一些大的社会问题。”但他总是追逐着未知世界，他说：“如果你真诚地去做，就会变成对社会有用的东西。”

十大科学才子：陶哲轩

7. 陶哲轩，31 岁，数学家

着名数学家陶哲轩是一位密码破译高手，现在他即将采用一种新方法，这种方法能有效的将破碎的信息拼凑在一起，提到这种方法，陶还要感谢加利福尼亚大学洛杉矶分校的日托呢。这位加利福尼亚大学洛杉矶分校的数学家陶哲轩先生和来自附近州理工学院的埃马纽埃尔·坎德斯在日托外等着接孩子时，他们突发奇想，想搞清楚是否可以在即使只截取了一些零碎部分就能重组一个混乱信息。利用几何学、统计学和微积分学等这一领域的概念，他们不仅证明了它的可能性，还指出了解决这一难题的方法。他们的技术正在被任何一个想整理混乱信息的人采用，例如，中央情报局利用它窃听电话内容或者医生用它修复脑电图中出现的斑点。

这个作品是陶的经典之作：在新领域取得突破性发现需要掌握数学光谱技术。正是这种独创性让陶赢得了今年的菲尔兹奖，它是与诺贝尔奖地位相同的数学大奖。他自 1986 年就投身这一领域，是这一领域中最年轻的数学家，当时年仅 13 岁的陶，在两年前就在国际奥林匹克数学竞赛中获胜，成为当时最年轻的奥林匹克数学竞赛获胜者。他在 21 岁从普林斯顿大学获得哲学博士学位后，在接下来的十年中，“他确实是以暴风雨般的形式席卷整个数学界，”洛杉矶加州大学物质科学院院长、数学教授陈繁昌说。陶至少已经在数学的五大分支中取得了重要发现，陈说：“这些领域的资深人士都敬畏的搔首而视。”

陶最卓着的成就给一项持续了几个世纪的数学探索画上句号。他利用几个领域的技术揭开了质数的另一个让人惊异的模式。但在陶看来，不同数学领域之间存在的传统分界线似乎根本就不存在。“它们以某种形式相互联系，”陶的加利福尼亚大学洛杉矶分校的同事约翰·加内特赞同地表示：“你必须以陶哲轩的眼光看待这一切，而且其他人也确实如此。”

十大科学才子：萨拉·西格

8. 萨拉·西格，35 岁，遥远行星搜寻者

西格的模拟实验向天文学家讲述了地外生命或许将在其他行星上留下怎样的指纹。在过去 10 年，天文学家已发现 200 颗环遥远恒星轨道运行的新行星，而这其中并无一颗行星看似地球。华盛顿卡

内基研究所天文学家萨拉·西格认为这种状况将会有所改变。她已想出一种弄清楚遥远行星拥有何种大气层的方式，试图证明类似我们地球一样的行星遍布银河系。

关于遥远行星构成的资料非常少，西格通过想象从数千光年远的地方看地球的样子，制成了外太阳系行星的早期模型。随后，她以无数种不同的方式对她的“地球”做出改变——使其体积扩展一倍，或是为大气层增加陌生的气体——每次她都要重新计算其外貌。西格的天体库不仅显示了新发现行星可能的构成，也为天文学家的探寻目标提供了思路。旧金山州立大学天文学家黛布拉·费舍尔说：“她正在对那些我们只有少量或是没有任何实验数据的天体做出预测。而她的那些预测推动了我们的观测。”黛布拉·费舍尔所在的研究小组因发现太阳系外多数已知行星而享有很高声誉。

实际上，西格的模型在发现一个遥远行星周围的第一个大气层时派上了用场。1999 年，西格刚从哈佛大学获哲学博士后一个月，天文学家发现了一颗行星，这颗行星运行在能从地球看到的每条轨道期间，经过其母恒星的前面，阻碍少量但却能探测的星光。西格将她对这颗行星所了解的数据加入到模型上，并预测这颗如木星模样的“气体巨人”在其大气层中存在钠和钾。两年后，天文学家进行了搜索，真的发现了这些化学元素的“签名。”

迄今，西格已使用该方法对约 12 颗行星的大气层进行制表，如今她正在寻找诸如臭氧等“化学签名”，这一点可以说明同地球相似的条件，或许甚至还存在地外生命。西格正在将那些或许是由地外生命释放的每个潜在化学元素列成目录，并将每个化合物或许留在行星大气层的生物签名制成模型。这样一来，当望远镜捕捉到那些天体的最初迹象，我们马上会确认它是：另一个地球。

十大科学才子：埃里希·贾维斯

9.埃里希·贾维斯，41 岁，鸟语翻译家

贾维斯有关鸣禽的研究颠覆了我们以往对人类语言的许多看法。倘若你认为身旁有鸣禽齐声歌唱会是一种令人愉悦的体验，那么你可要三思了。步入贾维斯位于杜克大学的斑胸草雀饲养区之中，就好像进入一个有 200 个小车喇叭在同时尖叫的礼堂一般。当这位杜克大学神经科学家唱起雄性斑胸草雀的求爱歌曲的忠实版本时，房间里唯一悦耳的声音恰恰来自贾维斯本人，

贾维斯学会了雀科鸣禽的唱歌方式：通过倾听其他鸣禽并模仿它们的音调。这使得人类和雀科鸣禽都成为了“声音初学者”，这在动物王国属于一个罕见的特点(据悉，只有人类、鸣禽、蜂雀、鹦鹉、蝙蝠、海豚、鲸鱼和大象能做到这一点)。贾维斯的极富创造力的研究表明，这一共享能力扎根于类似的大脑结构中。这或许也说明，“语言”是被编入所有脊椎动物大脑中的先天能力。

贾维斯最初是通过在鸣禽唱完最后的小夜曲后立即对它们的大脑进行阻塞、划分和染色的方式，来研究鸣禽学习新歌的方法。这一过程证实，雀科鸣禽利用两个独特的神经系统通道来学习唱歌，一个位于大脑前部，一个位于大脑后部。他随后发现，在神经学层面上，人类（以及鹦鹉和蜂雀）也以相同的方式学习说话（和唱歌)。

不过，倘若每一群体独立进化这种“说话”能力的话，我们的大脑又如何全部使用同样的神经排列？贾维斯认为，答案就在于进化——当我们于三亿年前拥有共同祖先时，大脑就会适应语言变化。倘若他的观点正确，这说明甚至是复杂的人类语言也出自大脑的古老网络，同雀科鸣禽的“语言”来自相同的网络。

一旦神经科学家对这一基因蓝图有更为深刻的理解，他们就可以从理论上对其做出改变，或许是修复大脑损伤或只是增强我们学习新语言的能力。贾维斯正在扩展其研究领域。他希望在哺乳动物身上做更多研究工作，尤其是人类身上(尽管他认为不容易找到研究对象)。贾维斯说：“我知道自己是在同人类打交道，但也不仅仅是同人类。毕竟，要向这些鸟类学习的东西太多了。”

十大科学才子：刘易斯·万安

10.刘易斯·万安(Luis von Ahn)，27 岁，矩阵建造者

如果说电脑还有难题没有克服的话，他正在动用人的智慧解决这个问题。多数人工智能研究人员面对的一个艰巨的任务是，让电脑象人一样思考。卡内基·梅隆大学的教授.刘易斯·万安瞄准的却是另一个难题，他集合了数万人的论证技巧，去做那些似乎并不重要，电脑又难以解决的工作。万安开发的最受欢迎的软件完成的是电脑科学最难完成的任务：给互联网上的每一幅照片打上标签。单凭视角集体，电脑无法完美地区分照片，所以，万安的“ESPGame”网让网民们参加网上照片标注大赛。如果成功，你下次再到网上查到图片，就可以单刀直入了。

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现代物理学中的十一个重大问题

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摘要：(1) 经典电动力学认为加速运动的电荷能够辐射电磁波, 而量子力学指出电子在同一能级内做加速运动不能辐射电磁波，如何把它们统一在一起？(2) 引力场与电磁场的传播速度相等，在此背后是否有更本质的内涵？（3）在狭义相对论中，根据洛伦兹变换运动物体的长度在运动方向上收缩，是观察效应，还是本质规律，是否具有累积效应？（4）根据相对论空间与时间是密不可分的，空间与时间是等价的，并假设 1s=3.0×10^8m, 这样可以把国际基本物理量减少 1 个，并在此基础上根据量纲得到了质能方程，是否正确？（5）Einstein 一直把相对论称为场论，而人们总是把相对论称为研究时空的理论，那么引力场和时空到底是什么关系？（6）现代物理学的理论是根据对称产生的，可是我们周围的世界又是不对称的。（7）量子隐形传态中的两个相距甚远的关联粒子之间的‘相互作用’机制是什么？ （8）现代物理学认为电磁质量是引力质量的一部分，爱因斯坦曾经试图证明电子的电磁质量是电子引力质量的 2/3，电磁质量不可能是引力质量的一部分。(9) 超导体为何无电阻，目前超导体研究现状如何？ (10) 现代物理学认为弱相互作用和强相互作用只适用于微观世界，可是微观与宏观没有截然的界限，这显然存在着不协调性。 (11) 为什么物理学的基本方程都具有时间反演不变性？为什么绝对零度不可达到？[New York Science Journal. 2009;2(1):86-90]. (ISSN: 1554-0200).

关键词：电动力学；电荷；量子力学；质量；引力；物理学

20 年来，我先后查阅了大量的书籍和文献并请教了 800 多位专家,他们对此不熟悉，因此始终没有得到圆满的解答.您在理论物理方面有很深的造诣,因此特冒昧写信向您请教,殷切地希望您能给予解答，解答其中几个或某个问题亦可。

(1) 经典电动力学认为加速运动的电荷能够辐射电磁波,而量子力学指出电子在同一能级内做加速运动不能辐射电磁波，如何把它们统一在一起？如何解释下面的理想实验：假设在一个强引力场中有两个物体，一个不带电荷，另一个带有电荷，它们的引力质量相等（较小，它们之间的引力作用可以忽略），分别位于 A、B 两点，观察者处于强引力场中，两个物体同时由静止出发相向运动，它们所受的力相等。按照狭义相对论，它们的引力质量在任何时刻都相等，引力能量相等，可是由带电的物体将不断地辐射电磁波，那么能量从何而来？如果能量守恒把物体辐射的电磁波考虑在内，由于电磁力满足宇称守恒, 因此辐射电磁波的总动量应当为 0，由带电的物体速度应当大，能量仍然不守恒。

(2) 现代物理学认为光子不带有电量，作为创建“量子场论路径积分”的核心人物费曼先生，认为两个静电荷之间的相互作用的传递过程是交换虚光子来完成的，可用费曼图形象地表示。洛伦兹变换变换中的奇点如何解释，笔者认为光子应该带有电量，只是太小，实验中可能观察不到，这样便可圆满解释洛伦兹变换中的奇点问题。现代物理学认为中微子具有引力质量,但运动速度等于光速，如何利用洛伦兹变换解释这个问题，如果是亚光速粒子，宇称守恒与宇称不守恒矛盾，如何解释？引力场与电磁场的传播速度相等，在此背后是否有更本质的内涵？

（3）在狭义相对论中，根据洛伦兹变换运动物体的长度在运动方向上收缩，是观察效应，还是本质规律，是否具有累积效应？Einstein 曾说过：“……仅仅是外部关系的结果，不是一种真正的物理变化”。狭义相对论中‘钟慢、尺缩’属运动学效应，而广义相对论中。它们已属动力学效应，不应该是观察效应，而是物理的真实性。假设一个物体在运动方向上的长度为 l，开始由静止做加速运动，当速度达到 0.99c 时开始减速直到静止，那么开始与最后的长度是否相等？如果速度相等说明不具有累积效应，时间变换也符合洛沦兹变换，为什么现代物理学的实验证明（譬如μ子绕地运行）具有累积效应？时间与长度的变换符合洛沦兹变换，如果仅仅是观测效应，显然不符和 Einstein 的哲学观——“有一个独立于知觉之外的客观世界是一切自然科学的基础”，您如何理解这个关系？您如何理解双生子佯谬和潜水艇悖论？笔者重新分析了洛伦兹变换，说明了其真实含义，使狭义相对论时钟收缩效应与广义相对论的时钟收缩效应统一在一起，圆满地解释了双生子佯谬和潜水艇悖论，说明了相对性原理正确的原因,不知是否正确？

（4）根据相对论空间与时间是密不可分的，笔者认为空间与时间是等价的，并假设 1s=3.0×10^8m,这样可以把国际基本物理量减少 1 个，并在此基础上根据量纲得到了质能方程，不知是否正确？

（5）Einstein 一直把相对论称为场论，而人们总是把相对论称为研究时空的理论，那么引力场和时空到底是什么关系？笔者认为引力场的本质是时空，是相对时空。在此基础上说明了引力的传播速度等于光速，不知道是否正确？

（6）现代物理学的理论是根据对称产生的，可是我们周围的世界又是不对称的，李政道教授把分立对称性失效的原因列为 21 世纪科技界面临的四大难题之一,您如何理解这个问题呢？笔者根据现代科技理论提出了对称的相对性与绝对性原理，不知是否正确？广义相对论认为一切参考系都等价，无法确定整个宇宙的运动状态，可是大爆炸理论却认为这个宇宙处于膨胀阶段，如何理解这一关系？能量守恒定律认为能量是不可创造，质量守恒定律认为质量是不可创造，大爆炸理论认为能量、物质（质量）、空间、时间已经被一个无限小的点爆炸创造，并且是在四大皆空发生的，如何理解这些关系？

（7）量子隐形传态中的两个相距甚远的关联粒子之间的‘相互作用’机制是什么？ 电荷究竟是什么（实体？属性？运动效应？振荡模式？）？ 基本粒子质量谱可能与何因素有关？在大统一理论中为何存在“大沙漠”现象，其物理原因是什么

？ 真空破缺的动力学机制是什么？基本粒子是如何生成的？ 真空为何存在零点振荡能？能量来自何处？

（8）电子的电磁质量问题。现代物理学认为电磁质量是引力质量的一部分，爱因斯坦曾经试图证明电子的电磁质量是电子引力质量的 2/3，笔者通过十八年的思考后认为电磁质量不可能是引力质量的一部分，原因有六个方面：第一，物体的静止质量是内禀的，是个常数，有人认为电磁质量是应该与静止质量有关的，电磁场的能量由电荷决定，电量与带电体的运动状态无关，引力质量与运动状态有关。当电子加速运动的时候，其电量是不会改变，所以其电磁质量不会发生改变，电磁质量不满足 Lorentz transformation，因此把电磁质量作为引力质量的一部分存在着不协调性——只要维持电子电荷值不变的观念，这个问题不管怎么也解释不通。这中间，要么质速关系式错了，要么就是电子电荷值不变的信念错了，然而这与实验事实又高度一致。由于公式 E＝mc2，物体的引力结合能具有(负)质量，因而系统总质量不等于各部分质量之和．而在麦克斯韦理论中，作为线性理论的直接结果，电荷(类比于质量)是严格可加的．第二，电磁力存在吸引与排斥两种状态，只有物体带电时才有，而引力是永远存在的；电子、质子等带电粒子之间的电磁力远大于万有引力，电磁质量远大于引力质量，电磁质量不可能是引力质量的一部分；电子激发的电磁场的能量小于电子的电磁质量，正如物体激发的引力场能量小于引力质量的能量一样。根据质速关系引力质量可以连续变化，而电荷和电磁场呈量子化分布，现代物理学未让量子力学进入的唯一领域是引力和宇宙的大尺度结构，将引力场量子化遇到无穷大的困难。重整化可以消除无限大的问题，但是由于重整化意味着引力质量的作用力的强度的实际值不能从理论上得到预言，必须被选择以去适合观测，因此重整化有一严重缺陷。目前要取得进展，能够建议采用的最有力的方法，就是在企图完成和推广组成理论物理现有基础的数学形式时，利用纯数学的所有源泉，并在这个方面取得每次成功之后，试着用物理的实体来解释新的数学特色。第三，电磁质量具有正负，电磁质量应当相反，而物体的引力质量无此区别。电荷分为正负，但电场的能量密度却总是正的，所以积分得到的电磁能量总是正的，因而电磁质量也总是一个正值。根据牛顿第二定律，惯性质量是表征当物体受到外力作用的时候，物体运动状态改变的难易程度，即物体保持原来运动状态的本领大小的物理量。这个和电荷的正负无关，所以正负电子可以具有相同的惯性质量。当正负电荷中和的时候，电磁质量增加，引力质量没增加，但正负电荷中和会释放原来具有的电势能，即原来的电磁质量会转化为别的能量，如正负电荷中和释放两个光子，则原来的电磁质量就转化到了光子中。那么转化的机制是什么？同种电荷的电磁力相互排斥，异种电荷的电磁力相互吸引，电荷之间的作用力依靠电磁场来传递，为什么电磁场的能量都是正值？一个中性原子的电磁场的能量为 0，说明正负电荷激发的电磁场的能量相反。第四，Einstein 的广义相对论是引力理论，把引力场量子化给出引力场的量子成为引力子，它应具有自旋为 2，和 lectriec field 的量子——光子性质很不相同。近年来理论上对超对称性的探讨提供了新的可能性，超对称性在自旋不同的粒子间建立了联系，因此就有可能把引力相互作用和其它相互作用联系起来，通过超对称性建立的四种相互作用的统一理论称为超大统一理论。但是根据对称的相对性与绝对性原理，超对称的工作是没有止境的。超对称要求除引力子

外，还应当有自旋 3/2 的引力微子存在，但是实验上并没有发现它的存在。另外量子化的引力理论遇到了难以克服的无穷大困难；第五，引力质量都占有一定的空间，也就是具有体积，而电磁质量没有体积，因此量子电动力学的点模型观点是正确的。第六，电磁质量和引力质量可以分离，存在 Maxwell 理论中脱离物体携带能量的场。最近，法国里昂的科学家发现了有四个中子组成的粒子，又称为“零号元素”。最新的实验表明，中微子具有引力质量，大约为电子引力质量的 50000 分之一。中微子具有引力质量但是不带有 electric charge——电磁质量。现代物理学认为除了带电介子外，还存在中性介子，其（引力）质量恰好等于或者近似等于（其实相等）带电介子的（引力）质量，性质相似。Einstein 指出了波函数坍缩过程与相对论之间的不相容性，Einstein 的这一分析是关于量子力学与相对论的不相容性的最早认识。Einstein 晚年已经认识到 electric charge 没有引力质量的问题，指明引力场和 lectriec field 是逻辑上毫无联系的部分。文章首先回顾了惯性质量和引力质量之间的关系的认识，然后分析了经典电动力学和量子电动力学对于电磁质量计算结果的差异，从六个方面分析了电磁质量不是引力质量的一部分，通过把引力质量与电磁质量区分开来，说明了希格斯机制的引入是多余的，希格斯粒子根本不存在,把电量的度量单位库仑与质量的度量单位千克统一起来，从而把国际基本物理量减少为 5 个，从根本上解决了升降机中静止电荷的辐射问题和狭义相对论中的奇点问题——光子的静止质量问题，提出了 Lorentz transformation 变换不适用于电磁质量，量子力学的统计观点不适用于引力质量，从根本上解决了“薛定谔猫佯谬”的问题，把质能方程从引力质量推广到电磁质量，预言了新的能量来源，定性地解释了类星体的爆炸，通过电磁质量的量子化解决了夸克禁闭问题，解释了光速不变性原理、光速为物体运动的极限速度的原因与广义相对论的红移危机，说明了引力与电磁力的传播速度相等的原因，预言了光子带有极其微弱的电量、质子与电子辐射的光子的能量相反以及引力波为横波，否定了“超光速问题”，分析了中微子问题、量子力学的基础，根据引力场的 space-time 本质的观点从根本上解决了 Einstein 与哥本哈根学派之间关系量子力学基础之间的争论，不知是否正确？

(9) 超导体为何无电阻，目前超导体研究现状如何？超导中的库柏对为何两个电子的自旋方向相反，动量方向也相反？高温超导的微观机理是什么？可否发现室温超导体？现代科学如何认识地磁场形成的原因的，以及磁偏角？ 波的衍射条件背后是否存在更本质的规律？全反射现象说明了光在同一种介质中并非一定沿直线传播，是否与广义相对论矛盾？能量最低原理认为物体只有处于最低状态才稳定，在这些现象背后是否存在着更本质的规律？

(10) 现代物理学认为弱相互作用和强相互作用只适用于微观世界，可是微观与宏观没有截然的界限，这显然存在着不协调性。现代物理学已经把电磁力与强相互作用的统一问题起来，可是对于电磁力同种电荷相互排斥，而对于强相互作用作用力的方向相反，如何理解这一关系？笔者指明了四种相互作用力之间的关系，万有引力与弱相互作用、电磁力与强相互作用是互为反作用力，在此基础上分析了宇宙常数、暗物质与暗能量、引力佯谬和密度佯谬、太阳角动量的逃逸的问题，从根本上否定了宇宙大爆炸理论和黑洞的存在，定性地解释了“DI 海格立斯双星进动”问

题和轻子为何不参与强相互作用，对统一场论的研究可能会有所帮助，不知是否正确？为何基本相互作用都是汤川型强相互作用？

(11) 基本物理常数的数值会随时间改变吗？自然界的基本常数为什么具有现在的数值？为什么物理学的基本方程都具有时间反演不变性？为什么绝对零度不可达到？为什么热水比冷水冻结快些（Erasto Mpemba 问题）？运动物体的温度会改变吗？开放系统的熵具有什么物理意义？湍流形成的机理是什么？地球磁场极性颠倒的原因是什么？南极空洞是怎么形成的？生物体内有核反应吗？地震前的地光是怎么形成的？ 为什么闪电多‘之'字形少球形？能否解决强关联多电子系统的基态和元激发问题？能否解决低维凝聚态物理新现象的理论问题？ 何时能揭开狄拉克的大数之谜？可控轻核聚变能否实现？ 激光热核反应的点火条件（劳森判据）能否达到？常温核聚变能否实现？冷核聚变能否实现？量子混沌确实存在吗？最后一个超重元素的质子数是多少？热中子辐射俘获疑问的实质是什么？原子核磁矩能否准确计算出来？ Gamow-Teller 巨共振问题 gA（核内核子）!=gA（自由核子）能否解决？ 奇异电子峰是怎样形成的？ＥＭＣ效应能否解决？质子自旋危机能否解决？电子与核散射中，纵向响应形状因子问题能否解决？有限核的结合能与能极能否一一准确算出来？夸克－胶子等离子体（ ＧＰ）物质态是否真的存在？ 宇宙种子磁场的来历是什么？ 有无胶子球存在？存在第四代基本粒子吗？ e-u-t 之谜何时能解开？亚夸克结构仅仅是推测吗？质子的寿命有多长？ 电子有无结构？ 光子有无结构？有无奇异物质存在？Ｃ，Ψ物理中的ρ π疑难能否解决？

20 年来我把自己的思考观点写成了文章的形式，文章用rar形式压缩而成，另外有我关于数学方面的几个问题的思考。我殷切地希望读者能提出宝贵的意见，联系方式：xiandaiwulixue@21cn.com。

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Dialysis and its Application

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Abstract: Dialysis is a renal replacement therapy that provides an artificial replacement for kidney disfunction, and it is a life support treatment but not treat kidney diseases. Dialysis is based on the principle of the diffusion of solutes along a concentration gradient across a semipermeable membrane. There are three main types of dialysis: hemodialysis, peritoneal dialysis and hemofiltration. [New York Science Journal. 2009;2(1):91-96]. (ISSN: 1554-0200).

Keywords: blood; dialysis; hemodialysis; hemofiltration; kidney; peritoneal; renal

1. Introduction

Kidney is an important organ in animal to remove waste from the body, such as potassium and urea, as well as free water from the blood. Under the healthy condition, kidneys remove waste products from the blood and also remove excess fluid in the form of urine (Minuth et al. 2008). Disfunction kidney could loss these functions, which is a serious disease that damages many people's normal life and even be fatal. There are millions of people who are suffered from kideny disfunction. Dialysis is a renal replacement therapy that provides an artificial replacement for kidney dysfunction, and it is a life support treatment but not treat kidney diseases, which is based on the principle of the diffusion of solutes along a concentration gradient across a semipermeable membrane. In dialysis, blood passes on one side of a semipermeable membrane, and a dialysis fluid is passed on the other side. By altering the composition of the dialysis fluid, the concentrations of undesired solutes (potassium and urea, etc) in the fluid are low and desired solutes (such as sodium) are at their natural concentration as in healthy blood. The undesired solutes, i.e. waste, then diffuse across the membrane into the dialysis fluid and are removed, and the desired solutes will be kept in the natural concentration. Dialysis may be used for very sick patients who have suddenly lost their kidney function or for quite stable patients who have permanently lost their kidney function. Dialysis treatments could play the functions to remove waste from the body, instead of the kidney's function. Dialysis lets the blood into the comparative normal condition for the renal dysfunctional patients (Verbeke et al. 2007). Bacterial kidney disease is a systemic disease that threatens the expansion of both cultured and wild salmonids worldwide (Eissa, 2006). The progressive increase in the mean age of dialysis patients associated with increasing comorbidity factors such as the presence of cardiovascular disease and diabetes have significantly worsened patients' clinical status and tolerance to hemodialysis (Santoro et al. 2007).

2. Theory of Dialysis

Dialysis is based on the principle of the diffusion of solutes along a concentration gradient across a semipermeable membrane. In dialysis, blood passes on one side of a semipermeable membrane, and a dialysis fluid is passed on the other side. By altering the composition of the dialysis fluid, the concentrations of undesired solutes (potassium and urea, etc) in the fluid are low and desired solutes (such as sodium) are at their natural concentration as in healthy blood. The undesired solutes, i.e. waste, then diffuse across the membrane into the dialysis fluid and are removed, and the desired solutes will be kept in the natural concentration (Fiore and Ronco 2007).

3. Types of dialysis

According to the techniques, there are three main types of dialysis: hemodialysis, peritoneal dialysis and hemofiltration.

(1) Hemodialysis

In hemodialysis, the patient's blood is passed through a tubing system to a semipermeable membrane which has dialysis fluid running on the other side. Through dialysis, the cleansed blood is then returned through the circuit system back to the body. Ultrafiltration occurs by increasing the hydrostatic pressure of the blood in the dialysis circuit to cause water to cross the membrane down a pressure gradient. The dialysis process is very efficient, allowing the treatment to be undertaken intermittently, usually two or three times a week, about four hours each time. The dialysis is normally done in the hospital, even it can also be done in a patient's home as the home hemodialysis. When dialysis taken, the tubes are kept in patient, and the patients in the dialysis treatment will be a handicapped status. Also, dialysis is high cost.

In contrast to peritoneal dialysis, in which transport is between fairly static fluid compartments, hemodialysis relies on convective tranport and utilizes counter current flow, where the diasylate is flowing in the opposite direction to blood flow in the extracorporeal circuit. Counter-current exchanges maintain the concentration gradient across the membrane at a maximum and increase the efficiency of the dialysis. The efficiency of waste clearance during hemodialysis is much higher than in natural kidneys. Therefore, dialysis treatments do not have to be continuous and can be performed intermittently, typically two or three times per week, or less. Fluid removal (ultrafiltration) is achieved by altering the hydrostatic pressure of the dialysate compartment, causing free water to move across the membrane along a pressure gradient. The dialysis solution is a sterilized solution of mineral ions. Urea and other waste products, such as potassium and phosphate, diffuse into the dialysis solution. However, concentrations of most mineral ions (e.g. sodium) are similar to those of normal plasma to prevent loss (Yucha 2004).

A. Dialysis prescription

A prescription for dialysis by a physician will specify various parameters for setting up dialysis machines, such as time and duration of dialysis sessions. In the United States, 3-4 hours each time and 2-3 times per week are typical. There are also a small number of patients who undergo nocturnal dialysis for 8 hours per night 6 nights per week.

B. Side-effects and complications

Hemodialysis usually also involves the removal of extra fluid, because most patients with end-stage renal failure pass no urine. The sudden removal of fluid on dialysis may cause side effects, which are usually proportionate to the amount of fluid which is removed. These potential side effects include low blood pressure, fatigue, breeding, chest pains, leg-cramps and headaches. Hemodialysis may cause inflammation. Since hemodialysis requires access to the circulatory system, patients undergoing hemodialysis have a portal of entry for microbes, which could lead to septicemia or an infection affecting the heart valves (endocarditis) or bone (osteomyelitis). The risk of infection depends on the type of access used. Blood clotting in the tubing and dialyser is a frequent cause of complications until the routine use of anticoagulants. While anti-coagulants have improved outcomes, they can lead to uncontrolled bleeding. Occasionally, people have severe allergic reactions to anticoagulants. In this case dialysis is done without anticoagulation or the patient is switched to an alternate anticoagulant. Heparin is the most commonly used anticoagulant in hemodialysis patients, as it is generally well tolerated and can be quickly reversed with protamine. A common alternative to heparin is citrate, that is suitable fo the patients who are allergic to heparin (Blossom et al. 2008).

C. Hemodialysis access

There are three primary modes of access to the blood in hemodialysis: an intravenous (IV) catheter, an arteriovenous (AV) Cimino fistula and synthetic graft. The type of access is influenced by factors such as the expected time course of a patient's renal failure and the condition of his/her vasculature. Patients may have multiple accesses, usually because an AV Cimino fistula or synthetic graft is maturing, and a catheter is still used.

D. Catheter

Catheter access, sometimes called a central venous catheter (CVC), consists of a plastic catheter with two lumens (or occasionally two separate catheters) which is inserted into a large vein (usually the vena cava, via the internal jugular vein or the femoral vein) to allow large flows of blood to be withdrawn from one lumen, to go into the dialysis circuit, and to be returned via the other lumen. However, the blood

flow is almost always less than that of a well functioning fistula or graft. They are usually found in two general varieties, tunnelled and non-tunnelled.

Tunnelled catheter access involves a longer catheter, which is tunnelled under the skin from the point of insertion in the vein to an exit site some distance away. They are usually placed in the internal jugular vein in the neck and the exit site is usually on the chest wall. The tunnel acts as a barrier to invading microbes and as such tunnelled catheters are designed for short to medium term access, as infection is still a frequent problem.

Non-tunnelled catheter access is for short term access, up to about 10 days, but often for one dialysis session only, and the catheter emerges from the skin at the site of entry into the vein.

Aside from infection, venous stenosis is another serious problem with catheter access. The catheter is a foreign body in the vein, and often provokes an inflammatory reaction in the vein wall, which results in scarring and narrowing of the vein, often to the point where it occludes. This can cause problems with severe venous congestion in the area drained by the vein and may also render the vein, and the veins drained by it, useless for the formation of a fistula or graft at a later date. Patients on longterm hemodialysis can literally 'run-out' of access, so this can be a fatal problem.

Catheter access is usually used for rapid access for immediate dialysis, for tunnelled access in patients who are deemed likely to recover from acute renal failure, and patients with end-stage renal failure, who are either waiting for alternative access to mature, or those who are unable to have alternative access. Catheter access is often popular with patients, as attachment to the dialysis machine doesn't require needles. However the serious risks of catheter access noted above mean that such access should only be contemplated as a long term solution in the most desperate access.

The hemodialysis machine performs the function of pumping the patient's blood and the dialysate through the dialyzer. The newest dialysis machines on the market are highly computerized and continuously monitor an array of safety-critical parameters, including blood and dialysate flow rates, blood pressure, heart rate, conductivity, pH, etc. If any reading is out of normal range, an audible alarm will sound to alert the nurse to se the patient condition.

E. Water system

An extensive water purification system is a basic equipment for hemodialysis. Since dialysis patients are exposed to vast quantities of water, which is mixed with the acid bath to form the dialysate, even trace mineral contaminants or bacterial endotoxins can filter into the patient's blood. Because the damaged kidneys are not able to perform their intended function of removing impurities, ions that are introduced into the blood stream via water can build up to hazardous levels, causing numerous symptoms including death. For this reason, water used in hemodialysis is typically purified using reverse osmosis. It is also checked for the absence of chlorine ions and chloramines, and its conductivity is continuously monitored, to detect the level of ions in the water.

F. Dialyzer

The dialyzer, or artificial kidney, is the piece of equipment that actually filters the blood. One of the most popular types is the hollow fiber dialyzer, in which the blood is run through a bundle of very thin capillary-like tubes, and the dialysate is pumped in a chamber bathing the fibers. The process mimics the physiology of the glomerulus and the rest of the nephron. Pressure gradients are used to remove fluid from the blood. The membrane itself is often synthetic, made of a blend of polymers such as polyarylethersulfone and polyamide. Dialyzers come in many different sizes. A larger dialyzer will usually translate to an increased membrane area, and thus an increase in the amount of solutes removed from the patient's blood. Different types of dialyzers have different clearances for different solutes. I suggest that the dialyzer should be discarded after each treatment and not shared among patients.

G. Pre-dialysis

A dialysis machine should be available first. There are many models of dialysis machines, but typically in modern machines there will be a computer, CRT, a pump, and facility for disposable tubing and filters. The filters (the actual artificial kidneys) are cylindrical, clear plastic outside with the filter material visible inside. They are perhaps 15-18 inches long, and 2-3 inches thick. They have tubing connectors at both ends. The nurse will set up plumbing on the machine in a moderately complex pattern that has been worked out to move blood through the filter, allow for saline drip, allow for various other

medications/chemicals to be administered. How the plumbing is set up may vary between models of machine and they types of filters.

The pump does not directly contact the blood or fluid in the plumbing — it works by applying pressure to the tubing, then moving that pressure point around. Think of a disk with a protrusion in it. Put this into a close fitting 270 degree enclosure. Put plastic tubing between the enclosure and the disk, entering and exiting in the 90 open degrees. Now imagine the disk turning. It will put pressure on the tubing, and the pressure point will roll around through the 270 degrees, forcing the fluid to move. It is characteristic of dialysis machines that most of the blood out of the patients body at any given time is visible.

The patient arrives and is carefully weighed. Standing and sitting blood pressures are taken. Temperature is taken.

Access is set up. For patients with a fistula this means inserting two large gauge needles into the fistula. This is painful and a local anaesthetic injection could be done.

When access has been set up, the patient is then connected to the preconfigured plumbing, creating a complete loop through the pump and filter.

F. Dialysis

The pump and a timer are started. Hemodialysis is underway. Periodically (every half hour, nominally) blood pressure is taken. As a practical matter, fluid is also removed during dialysis. Most dialysis patients are on moderate to severe fluid restrictive diets, since kidney failure usually includes an inability to properly regulate fluid levels in the body. A session of hemodialysis may typically remove 2-5 kg of fluid from the patient. The amount of fluid to be removed is set by nurse according to the patient's estimated dry weight. This is a weight that the care staff believes represents what the patient should weight without fluid built up because of kidney failure. Removing this much fluid can cause or exacerbate low blood pressure. Monitoring is intended to detect this before it becomes too severe. Low blood pressure can cause cramping, nausea, shakes, dizziness, lightheadedness, and unconsciousness. During dialysis, occasionally, patients have low blood pressure and lose consciousness. Often this is temporary and passes after the head is placed down for a short time.

G. Post-dialysis

At the end of the prescribed time, the patient is disconnected from the plumbing - blood lines. Needle wounds are bandaged with gauze, held for up to 1 hour with direct pressure to stop bleeding, and then taped in place. The process is similar to getting blood drawn, only it is lengthier, and more fluid or blood is lost.

Temperature, standing and sitting blood pressure, and weight are all measured again. Temperature changes may indicate infection. BP discussed above. Weighing is to confirm the removal of the desired amount of fluid.

Care staff verifies that the patient is in condition suitable for leaving. The patient must be able to stand, maintain a reasonable blood pressure, and be coherent. Different rules apply for in-patient treatment.

H. Post-dialysis washout.

Following haemodialysis, patients may experience a syndrome called "washout". The patient feels weak, tremulous, extreme fatigue. Patients report they "are too tired, too weak to converse, hold a book or even a newspaper." It may also vary in intensity ranging from whole body aching, stiffness in joints and other flu-like symptoms including headaches, nausea and loss of appetite. The syndrome may begin toward the end of treatment or minutes following the treatment. It may last 30 minutes or 12-14 hours in a dissipating form. Patients though exhausted have difficulty falling to sleep. Eating a light meal, rest and quiet help the patient cope with washout until it has 'worn away.

(2) Peritoneal dialysis

In peritoneal dialysis, a special solution is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a semipermeable membrane. The fluid is left there for a period of time to absorb waste products, and then is removed through the tube. This is usually repeated a number of times during the day. Ultrafiltration occurs via osmosis in this case, as the dialysis solution is supplied in varying osmotic strengths to allow for some control over the amount of fluid to be removed. The dialysis process in this case is less efficient than hemodialysis and is carried out daily, but the ultrafiltration process is slower and gentler.

Peritoneal dialysis works on the principle that the peritoneal membrane that surrounds the intestine, can act as a natural semipermeable membrane, and that if a specially formulated dialysis fluid is instilled around the membrane then dialysis can occur, by diffusion. Excess fluid can also be removed by osmosis, by altering the concentration of glucose in the fluid.

Dialysis fluid is instilled via a peritoneal dialysis catheter, which is placed in the patient's abdomen, running from the peritoneum out to the surface, near the navel. This is done as a short surgery. Peritoneal dialysis is typically done in the patient's home and workplace, but can be done almost anywhere; a clean area to work, a way to elevate the bag of dialysis fluid and a method of warming the fluid are all that is needed. The main consideration is the potential for infection with a catheter; peritonitis is a commonest serious complication, and infections of the catheter exit site or tunnel are less serious but more frequent. Because of this, patients are advised to take a number of precautions against infection (Rippe et al. 2007).

(3) Hemofiltration

Hemofiltration is a similar treatment to hemodialysis, but in this case, the membrane is far more porous and allows the passage of a much larger quantity of water and solutes to pass across it. The fluid which passes across the membrane is discarded and the remaining blood in the circuit has its desired solutes and fluid volume replaced by the addition of a special hemofiltration fluid. It is a slow continuous therapy with sessions typically lasting 12-24 hours, usually daily. This, and the fact that ultrafiltration is very slow and thus gentle, makes it ideal for patients in intensive care units, where acute renal failure is common. A combination of hemofiltration and hemodialysis, called hemodiafiltration (incorporating a hemofilter to a standard hemodialysis circuit), is being used in some centres for chronic maintenance therapy (Mahdavi-Mazdeh et al. 2008).

Peritoneal dialysis (PD) has been used as a home dialysis therapy for renal replacement for more than 30 years. A high proportion of PD patients are overhydrated. Clinical assessment of dry weight in PD patients is difficult and further complicated by the paucity of signs and symptoms indicative of dehydration. Bioimpedance analysis technique has been considered as a potential tool to measure body fluid non-invasively, inexpensively and simply (Zhu et al. 2006).

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