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SUBJECT: Short Course on Engineering Aspects
of Aerospace and Undersea Medicine,
MIT, August 1969 - Case 610

DATE: October 1, 1969

FROM: D. J. Belz

Dr. S. P. Vinograd - NASA/MM:

In response to your request, I am transmitting to you a copy of my notes from the short-course on aerospace and undersea medicine which you organized together with Dr. Young. While these notes are thought to be accurate, no attempt has been made to verify their contents with the lecturers whose presentations are summarized therein. The notes therefore constitute informal working papers subject to revision and emendation.

D. J. Belz
D. J. Belz

1025-DJB-dcs

Attachment, 126 Pages

Copy without attachment to:

D. A. De Graaf

D. R. Hagner

I. M. Ross

M. P. Wilson

Central Files

WORKING PAPERS

→ Actually on the Visual Sense

DR. JOHN L. BROWN - SPECIAL SENSES

KENT STATE U. - V.P. Soc Academic Affairs

Going to U.S. Rochester.

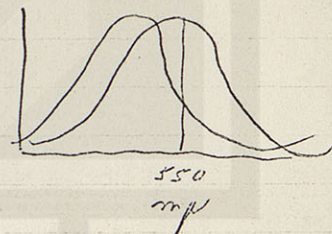
Vestibular sense

Visual senses (Brown's primary interest).

4 or 5 quanta are sufficient to stimulate the retina.

Wavelength Range
of Sensitivity of Eye

370 nanometers 760 nanometers (1 nanometer = 1 millimicron)



Fish native to depths below 30 meters
don't have color vision. For

Human Eye operates over 3 orders of magnitude
of illumination - adaptation from low to high level takes
no more than 3 minutes; adaptation from high to low illumination
takes up to 1/2 hour.

Visual Acuity: Minimum RESOLVABLE ANGLE IN
MINUTES OF ARC

Visual acuity of 1 = 20:20 vision.

→ Eye can resolve a 1/2 arc second width of a line.

Distance to observer

15 observer is

100 miles from target,

target must be $1.5 \times 100 = 150$ ft. in diameter; 5 ft. in height, but only 2 ft. in width; 5 ft. in height.

WORKING PAPERS

WORKING PAPERS

Temporal resolution of the eye

A dark adapted eye can sum energy over 0.1 sec.

A light " " " " " " 0.01 sec. $\in$ Sine temporal resolution.

$\therefore$ Ability to detect light is gained at the expense of temporal resolution.

inhibitory region
drops out of
dark adapted
animals.

Retina

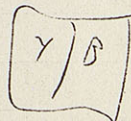
Pattern Vision:



appears darker than

There are spatial organizations of receptors for color.

Polarization of red, ^{green} and yellow, blue.



OFF responses



Some(?) retinal nerve cells are line element detectors that are sensitive to the orientation of fine elements. speculation is that this may be basic to human visual pattern recognition.

WORKING PAPERS

Space Hazards to vision

1. high acceleration

a. Impeded flow of blood to head results in blackout at $2\frac{1}{2}$ to 3 g's relaxed or 5 g's if tense.
Visual blackout.

From 1.1 to 0.6

Visual acuity decreases with increasing acceleration from 1.1 to 9 g's.

Zero g has no known enhancement or degradation of visual acuity.

2. Reduction in O_2 partial pressure elevates detection threshold of brightness. Reduction of SP_{O_2} to level equivalent to ≈ 3000 ft. can be reliably detected.

Smoking cigarettes reduces sensitivity of vision (elevates threshold)

3 cigarettes in succession have same effect as 3000 elevation equivalent PO_2 .

15-20 seconds direct looking at sun results in retinal burn.

Light available from sun is adequate for photopic vision out to 3 times photos radius from sun.

DAVID ROBINSON, JOHNS HOPKINS - VISUAL ACTIVITY IN MOVING IMAGE, VS. FIXED IMAGE.

WORKING PAPERS

CHRONOBIOLOGY FRANZ HALBERG, Ph.D., U.S. Minnesota
 1st Authority in Field

Annual Reviews of Physiology

Biorhythms:

High Frequency
 up to 0.5 hours

Medial Frequency
 0.5 h to 6 days

Low Frequency
 + 6 days

Respiration
 Electrocardiogram

Menstruation

there is a reliable 30 day rhythm in hormonal excretions from healthy men.

14 Blinded Mice

Normal Mice

Period of
 Rectal
 Temp. Variation

23.4 ± 0.3
 -0.2 HOURS

24 hours

^{Stoxin's}
 lethal dose in groups of 5 animals varies with 24 hour period.

Biorhythms confuse diagnosis in borderline situations.

Pathology: Catatonia found in men on 21 day period; all body
 functions mentioned studied had 24 day period.

ARCTIC NATIVES: 24 HOUR RHYTHMS HAVE BEEN DETECTED (DUE TO 24 HOUR SOCIAL PERIODICITY?)

FOR 26 YR. OLD WOMAN IN A CAVE FOR 3100'S. } women alone,
 RECTAL TEMP: } month back

Menstrual period shortened
 Circadian period lengthened

IMPLICATIONS FOR 23 1/2 HR. DAY

HUMAN BEINGS ~~TO~~ ~~IN~~ IN ARTIFICIAL ENVIRONMENTS DELIBERATELY
 VOID OF PERIODIC CLUES, ADAPT THEMSELVES TO "CIRCADIAN"
 PERIODS LONGER THAN 24 HOURS, BUT ^{RARELY} NEVER SHORTER THAN
 24 HOURS. ANIMALS HAVE HOWEVER SHOWN PERIODS SHORTER THAN 24 HRS. (20-25 HRS IN TRICORSE)

WORKING PAPERS

HUMANS IN SPITSBERGEN FOR UP TO 7 WEEKS LIVED ON A 21 HOUR DAY WITH WATCHES THAT READ 24 HRS AFTER 21 HOURS. MOST BODY FUNCTIONS STUDIED STAYED ON A 24 HR. BASIS, A FEW ADOPTED TO 21. HOURS, AND OTHERS AT SOME INTERMEDIATE VALUE.

~~WERE~~
~~ARE THERE~~ PERFORMANCE OR HEALTH DECREMENTS ASSOCIATED WITH THIS? EXPT. DID NOT MEASURE THAT.

[HALBERG WILL BE GLAD TO ANSWER QUESTIONS BY MAIL.]

LIFESPAN OF MIKE WAS SHORTENED BY REPEATED TIMESHIFTS OF 12 HOURS
D/NIGHT TO NIGHT/DAY ONCE A WEEK,
12/12 12/12

WORKING PAPERS

ASUTON
DR. GRAYBIEL: VESTIBULAR FUNCTION

Bony Labyrinth ~ somewhat smaller than, greater (25%).

MEMBRANOUS LABYRINTH IS IN OSSEOUS LABYRINTH.



Loss of Vestibular Function is not critical in
for vestibular normal living. Visual cues
make up for loss of Vestibular Function.

Rotating room:

Motionless subject, feels no effect.
Rotating head outside plane of room rotation
is ~~perceptible~~ noticeable.

~~From~~ VISUAL CUES TO ORIENTATION TAKE PRECEDENCE
OVER (DOMINATES) VESTIBULAR CUES IN NORMAL
ENVIRONMENT.

TRYING TO WALK A STRAIGHT LINE AFTER BEING
SPUN AROUND: DIFFICULT BECAUSE VESTIBULAR
CUES SWAMP VISUAL CUES IN UNUSUAL ENVIRONMENT.

PREDICTION OF SUSCEPTIBILITY TO MOTION SICKNESS: DIFFICULT
TO EXTRAPOLATE FROM ROTATING ROOM TO ZERO G.

IT IS POSSIBLE TO ADAPT TO MOTION SUCH THAT SUSCEPTIBILITY
TO MOTION SICKNESS IS GREATLY REDUCED.

WORKING PAPERS

JOHN SENDERS: GENERAL PSYCHOLOGY

CREW SELECTION

IN WWII

- PILOT SELECTION: STATISTICALLY, ODDS OF PICKING OUT AND ELIMINATING "BAD" RISKS WERE GOOD.
- MERCURY ASTRONAUTS: STATISTICAL SELECTION WAS INAPPLICABLE - LESS THAN OPTIMALLY QUALIFIED MEN WERE NOT GOOD ENOUGH
- THERE ARE MANY PSYCH-TESTS USED IN DISCRIMINATIVE DIAGNOSIS OF PSYCHOLOGICAL DISORDER. - SUCH TESTS NOT VERY USEFUL IN ASTRONAUT SELECTION.

IT IS UNLIKELY THAT WE SHALL HAVE STANDARD BATTERY TESTS FOR SELECTION OF ASTRONAUTS.

WHAT WE RELY ON IS SELECTION BY PEERS, AND A MAN'S PROVEN PERFORMABLE IN SIMILAR TASKS TO THOSE HE WILL BE CALLED ON TO CARRY OUT.

CREW TRAINING

TRANSFER OF SKILL FROM TRAINING TO ACTUAL SITUATION.
FACE VALIDITY NOT NECESSARILY A GOOD CHARACTERISTIC OF TRAINING SITUATION.

CURRENTLY, ADAPTIVE TRAINERS ARE USED: SPEED, ACCURACY REQUIRED, ETC. ARE INCREASED ADAPTIVELY. HOWEVEVER, MOVE SKILLS OF A MAN AS HIS SKILLS INCREASE. THESE HAVE BEEN USED SUCCESSFULLY FOR CONTINUOUS CONTROL PROCESSES WITH GOOD SUCCESS.

THERE IS NO REASON WHY "TEACHING MACHINES" CAN'T BE USED TO LEARN PROCEDURES.

→ MODERN TRENDS BACK TOWARD TRAINING SYSTEMS WITH A HIGH DEGREE OF FACE VALIDITY.

The hazards of operational systems are not generally reproducible in training systems. This aspect of face validity needs improvement in training situations.

Hypnosis, artificial rewards have been tried, but not with good success.

Some people can get involved with the training situation and perform as they will in operational situation. Other people, this is not so.

PERFORMANCE

MEASUREMENT OF WORK LOAD:

~~BETTER~~

- ANALYSIS OF TASKS TO DETERMINE "LOAD" THAT WOULD EXIST ON MAN IF HE WERE CARRYING IT OUT

- MEASUREMENT OF LOADS ON MEN DOING WORK

TECHNIQUES: MEASURE PHYSIOLOGICAL PARAMETERS INDICATIVE OF STRESS.

MEASURE INFORMATION PROCESSING CAPACITY OF MAN DOING TASK.

Competition between

PRIMARY TASK, e.g. AUDITORY

SECONDARY " , e.g. VISUAL helps measure 90% of total information processed by a man.

When Prim

BUT HUMANS DO NOT PROCESS INFORMATION AS A SINGLE CHANNEL DEVICE. Thus simultaneous performance of visual and auditory tasks is actually possible.

WORKING PAPERS

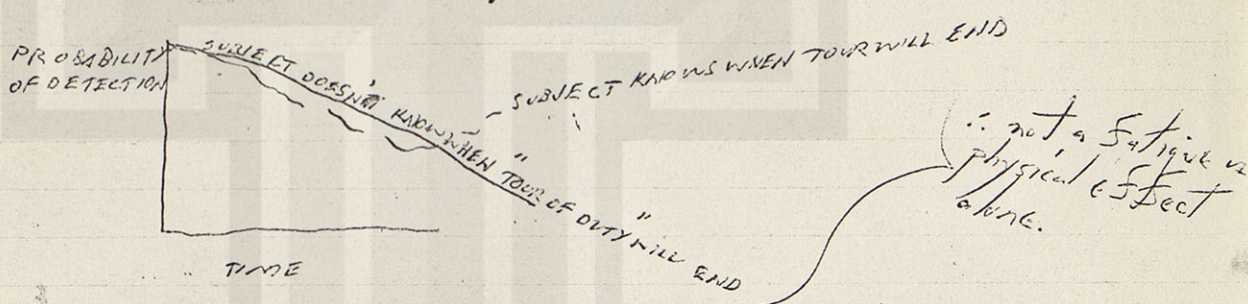
Better measure: Primary, secondary tasks both relying on same sensory input. (e.g. both visual or both auditory, or both kinesthetic)

→ SEE MORAY, ATTENTION, PERGAMON (IN PRESS)

↑ Excellent summary.

VIGILANCE

Example: Watch several rotating dial needles - report whenever one needle stops momentarily.
In general, watch and report unusual events.



A MONOTONOUS SITUATION WITH RARE STIMULI RESULTS IN LOSS OF VIGILANCE PERFORMANCE (i.e. detection of non-normal behavior).

→ Sender's Own Work: Check Vigilance by tracking eye position over a range of widely separated dials.
(NASA-CR-454)

CLEMENT, JEX, AND GRAHAM (SYSTEM TECHNOLOGY CORP.) extends work done in NASA CR-454 to the problem of prediction of human instrument layout for a Boeing 707. Completely analytical ESSort, but metrics VT was (that from system dynamics & Human Operator Functions. Signal prediction

WORKING PAPERS

→ Visual behavior (Eye movements)
 Transition Probabilities (LINKED VALUES OF INSTRUMENT
 & probability that eye will
 move from instrument A to B.)

PANEL LAYOUT DESIGNED
 So instruments with
 eye movement minimized

Detection of Shipboard psychological disorder in space crews.
 Symptoms would manifest themselves in conversation and
 operational behavior because, be sure, it would be
 detected by present psychological tests.

WORKING PAPERS

PLANETARY CHARACTERISTICS AND HAZARDS

DA. RAJOO (NASA/NIH)

LATEST MARS INFO. FROM MARRIAGER 6, 7.

↓ ^{90%} these are independent

PARAMETERS OF ATMOSPHERE (Temp., Pressure, density, chemical composition)

EARTH

Atmosph. Temp. 290°K
over ^{over} globe
over day/night or seasons

Atmos. Pressure at surface 1. BAR

? PRESS. $2 \times 10^{19} \text{ / cm}^2$

Composition
 $\text{N}_2 \sim 80\%$
 $\text{O}_2 \sim 20\%$
 H_2O
 CO_2
 O_3
:
:

The mass of Earth's oceans is 300 times its atmospheric mass.
" " " " atmosphere is 10^{-6} " total mass of Earth.

Jupiter may not have a solid surface.

MERCURY HAS NO ATMOSPHERE.

JUPITER: ESCAPE VELOCITY IS 60-Km/sec. $\therefore$ Not even H_2 escapes from Jupiter.

WORKING PAPERS

Babylonians recorded Venus' movements 4,000 years ago.
80% ^{actual} cloud cover would appear as 100% cloud cover with resolution available from earth. $\therefore$ there may be breaks in the cloud cover of Venus.

Composition of Venus' atmosphere (at top of clouds):

CO₂ (amount may vary from 1% to 100% of total atmosphere.)
Discovered by KUIPER, TERRESTRIAL OBSERVATION

Balloon descent from Earth H₂O 10⁻⁵ (trace)

Temp. of Venus at top of cloud layer: 205 to 210°K

Venus viewed by radio telescope (10 cm wavelength) indicated a surface temperature of 600°K.
{ or lower atmosphere temp. }

MARINER/VENUS showed surface (?) Temp. of 550°K

RUSSIAN VENUS SPACE PROBE INTO ATMOSPHERE OF 500°K.

VENERA 5, 6 MEASURED TEMPS. up to 600°K highest they could measure.

Surface pressure is 100 times that of earth.

VENERA (Russian) data shows 95% CO₂ atmosphere.

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MARS 80% to 100% CO_2 in atmosphere.

Surface pressure: 10 millibars.

MARINER 6, 7 polar light: Polar cap is thin - creates visible light polar cap.

Evidence of S Soldering in crust
Evidence of Seismicity

Pressure: 3 to 6 millibars.

JUPITER'S ATMOSPHERE CONTAINS METHANE AND AMMONIA.

WORKING PAPERS

ROBERT FOSTER: RESPIRATORY PHYSIOLOGY

OXYGEN TRANSPORT IN THE BODY!

DIFFUSION ^{ACROSS} ALVEOLAR WALLS
 MASS TRANSPORT (BLOOD FLOW)
 DIFFUSION ACROSS CAPILLARY WALL.

ROLE OF WATER VAPOR:

BLOOD GAS TENSION BREATHING AIR

ARTERIAL (mm Hg)	MIXED VENOUS (mm Hg)
PH ₂ O 47	47
PO ₂ 100	40
PN ₂ 573	573
PCO ₂ 40	45
TOTAL 760	TOTAL 705

A gas bubble in the body at sea level will resorb into the venous blood.

Continue

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Several extra atmospheres of H_2 has a narcotic effect equivalent to a cocktail. Helium is better in this respect.

- VENTILATION
- DISTRIBUTION
- DIFFUSION
- CIRCULATION

atelectasis - prevented by inert gas.

The ultimate limit on man's tolerance of high g 's is in his lungs. Alveolar blood vessels will burst. This limit could possibly be overcome someday by water breathing (lungs filled with water).

Medulla Oblongata (at top of spinal cord)
is the respiratory center.

A chemoreceptors around aorta and carotid arteries.
Sensitive to CO_2 in blood.

Cerebral spinal fluid: pH of spinal fluid is important in adapting to altitude changes.

PROGESTERONE INCREASES RESPIRATORY RATE.

WORKING PAPERS

JAMES WARREN CARDIOVASCULAR FUNCTION

A. ORGANIZED CIRCULATION

- I TISSUE NEEDS - CAPILLARIES
- II PERFUSION
- III TOTAL FLOW - CARDIAC OUTPUT

B. DISORGANIZED CIRCULATION

A. CAPILLARIES LOCAL CONTROL OF CAPILLARY FLOW (ARTERIOLES).

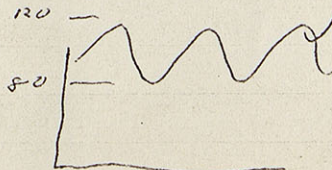
EXAMPLE: BLUSHING,
- USES: HEAT REGULATION, NERVOUS RESPONSE,
METABOLIC NEEDS.

TOTAL CROSS SECTIONAL AREA OF CAPILLARIES IS
GREATER THAN VEINS, ARTERIES. THUS FLOW VELOCITY
IN CAPILLARIES IS VERY SLOW.

CONTROLS EXIST ON BLOOD VOLUME
BLOOD CELL MASS
FLOW DISTRIBUTION

BLOOD VOLUME: ARTERIES 20%
CAPILLARIES 5%
VEINS 75%

MEAN ARTERIAL PRESSURE: 100 mm Hg



WORKING PAPERS

PULMONARY VASCULAR SYSTEM

RIGHT VENTRICLE 25. mmHg.

DIASTOLE = FILLING

SYSTOLE = EMPTYING

INACTIVE PHASE OF HEART ACTION

ACTIVE " " " "

HEART IS NOT ENTIRELY PASSIVELY
BUT HAS ACTIVE CONTROL OVER
ITS MAX. VOLUME INFILLING.

CARDIAL OUTPUT:

approximate { 8 l/min. RESTING NORMAL
5 to 15 " SHOCK
5 to 25 " CARDIAC FAILURE (PARTIAL FAILURE)
8 to 38 " NORMAL RANGE

VENOUS POOLING IN LEGS IN GOING FROM HORIZONTAL
TO VERTICAL (EXTRA BLOOD COMES FROM LUNGS)

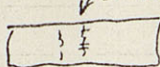
PUTTING MAN IN WATER OR A G-SUIT ELIMINATES
THE POOLING EFFECT.

DISORGANIZED CIRCULATION:

IN FAINTING: slowing of heart rate; fall in blood pressure.
classical

WORKING PAPERS

ALLERMAN: ELECTROCARDIOLOGY

NERVE FIBERS →  WAVE OF DEPOLARIZATION

GALVANOMETER
READING
(QRS Type)

(QRS Wave)

DEPOLARIZATION

RECOVERY (ANALOGOUS TO CONDENSER CHARGING)

REPOLARIZATION (T Wave) 

RECORDING TRACE IS A FUNCTION OF ORIENTATION OF LEAD "AXIS",
RELATIVE TO POLARIZED OBJECT.

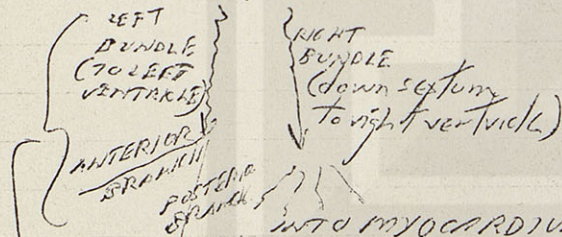
Assumptions underlying electrocardiography:

- 1) Homogeneous conducting body (human body - assumption)
Not really true but technique still works.
- 2) Resultant dipole remains stationary
- 3) Leads are equidistant from heart (Not valid)

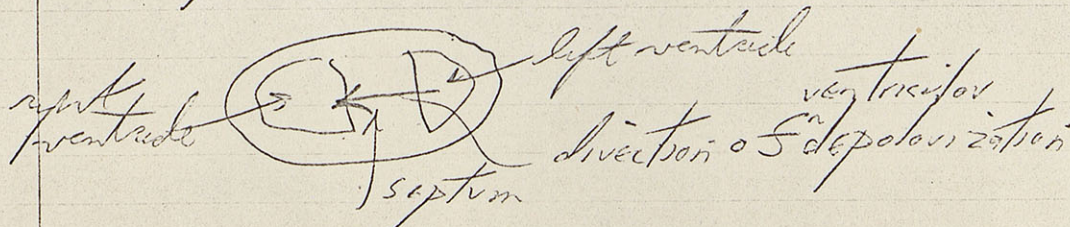
ANATOMICAL DETERMINANTS:

S.A. NODE AUTOMATICALLY DISCHARGES AT THRESHOLD DURING CHARGING
70 to 80 b.p.s/min.

A.V. NODE 80 to 120 milliseconds / sec, A.V. node gives



allows impulse to reach all of myocardium most simultaneously.



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0 to 10 millisees depolarization traveling thru septum
10 to 20 "

Mass of left ventricle is 5 times that of right ventricle.
In a normal heart, impulses from left ventricle dominate those from right ventricle.

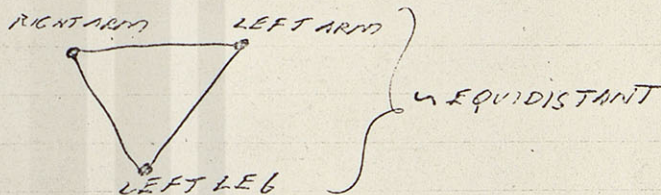
CONTRACTION CONTINUES THROUGHOUT REPOLARIZATION.



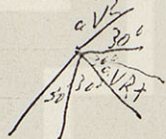
Standard 12-Lead electrocardiogram:
6 in a vertical (Frontal) plane
6 " " horizontal plane.

1913

EINTHOVEN TRIANGLE WITH UNIPOLARS

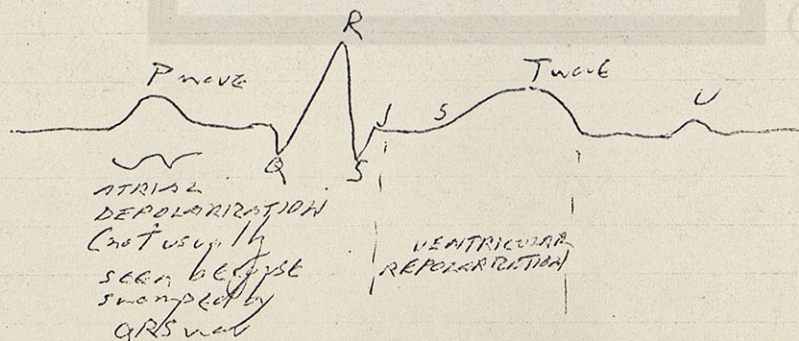


HEXAXIAL SYSTEM



CORRECTED HEXAXIAL REFERENCE SYSTEM

PROXIMITY ERROR: SIGNALS PICKED UP BY LEADS "NEAR" HEART, NOT BECAUSE OF HEART'S DIPOLE ORIENTATION.



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PRECARDIAL LEADS ($V_1, \dots, V_6$)

DIPLOLE CONCEPT OF HEART: VALID FOR MOST, BUT NOT ALL HEALTHY PEOPLE.
NOT USUALLY VALID FOR SICK HEARTS.

ELECTROCARDIOGRAPHIC MONITORING: CONTINUOUS MONITORING IN INTENSIVE CARE UNITS
GOOD FOR INSTANTANEOUS MONITORING OF SUDDEN ARRYTHMIA.

ELECTROCARDIOGRAPHY TELLS YOU WHAT HEART IS DOING, BUT NOT WHAT
REST OF BODY IS DOING. RESPONSE OF HEART IS FAIRLY NON-SPECIFIC.

USE OF ELECTROCARDIOGRAM FOR INFLIGHT MONITORING:

1959, 1960 ^{2 CROWN & LAND} ~~ROTHMAN~~, SOLVED PROBLEM OF
MONITORING DURING EXERCISE. THEY DISTINGUISHED
HIGH FREQUENCY FROM LOW FREQUENCY PHENOMENA.

high frequency component (0. to 1000 cps) are noisy;
they result from muscles.

low frequency - heart rate (0. to 60. cps)

Use of low-pass filter cuts down ^{muscle} noise.



Makes 30 to 40 minutes
for electrode to stabilize.

Apollo lead locations (anti-thoracic) are not
standard - great for detecting arrhythmias but lack of
a good data base makes interpretation difficult.

RECOMMENDED:

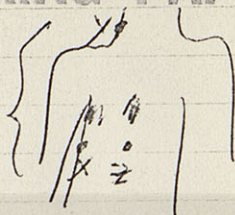
ORTHOGONAL, equally sensitive leads X, Y, Z .

FRANK ECG:

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1952 - orthogonal leads.

x, y, z potentials are
"equalized" by
an electrical net.



Do these provide same info
as conventional lead systems? Yes:

FRANK LEAD SIGNALS WERE TRANSFORMED INTO 12 STANDARD
LEAD SIGNALS. VERTICAL LEADS CORRELATED WELL IN SOME
~~CASES THE OTHERS NOT~~
PRECARDIAL LEADS DID NOT CORRELATE WELL,
PROBABLY DUE TO PROXIMITY ERROR.

FRANK LEAD SYSTEM DOES NOT HAVE A BUILT-IN
PROXIMITY ERROR.

45% OF 29 YEAR OLD
MEN HAVE THIS.

CORONARY ARTERY DISEASE; DEPOSITION OF LIPIDS (FATS) ON ARTERY WALL.
CORONARY HEART DISEASE; ADEQUATE SUPPLY OF BLOOD NO LONGER
REACHES HEART.

SYMPTOMS: NO PAIN AT REST
PAIN DURING EXERCISE

SUDDEN NARROWING OF ~~ARTERY~~ ^{ARTERY} LUMEN (?) DUE
TO BLOCKAGE BY FAT GLOBULE;
MYOCARDIAL INFARCTION.

WORKING PAPERS

JEROME KASSIRER: REGULATION OF FLUID AND ELECTROLYTE EQUILIBRIUM.

MAINTENANCE OF NORMAL QUANTITY AND COMPOSITION OF BODY FLUIDS IS A CRITICAL FUNCTION:

HEART - AFFECTED BY TOO MUCH BLOOD VOLUME

KIDNEYS - " " " " " " " " " " " "

REGULATION OF SALT AND WATER BALANCE:

~50% OF BODY WEIGHT IS WATER.

VOLUME OF BODY FLUIDS REMAINS FAIRLY CONSTANT FROM DAY TO DAY, DESPITE WIDE VARIATION OF WATER INTAKE.

WATER BALANCE:

INTAKE = 1500 cc Fluids

500 cc water in Soups
30%
H₂O

OUTPUT = 1500 cc URINE

800 INSENSIBLE WATER LOSS

2300 TOTAL
cc H₂O

VARIATIONS IN WATER INTAKE ARE REFLECTED IN URINE OUTPUT IN NORMAL PERSON.

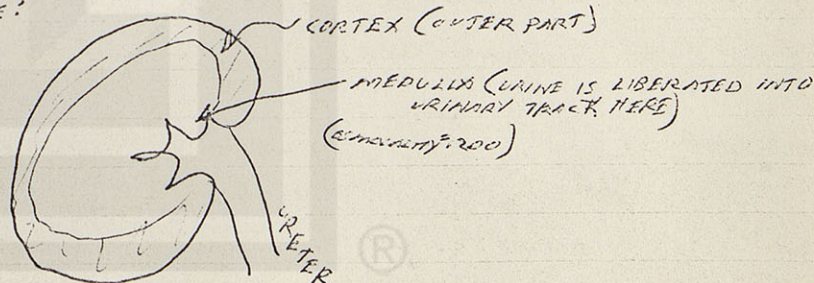
LOSS OF WATER FROM BLOOD RESULTS IN INCREASED NaCl CONCENTRATION. THIS CAUSES ANTIDIURETIC HORMONE WHICH CAUSES KIDNEY TO RELEASE LESS WATER; ALSO SENSATION OF THIRST OCCURS.

ANTIDIURETIC HORMONE IS FORMED IN NERVE CELLS AND STORED IN POSTERIOR PITUITARY GLAND.

ANTIDIURETIC HORMONE GETS TO KIDNEY.

KIDNEY STRUCTURE:

MODULAR UNIT OF THE KIDNEY IS THE NEPHRON.



KIDNEY STRUCTURE IS UNIQUE IN BODY

OSMOLALITY INCREASES FROM CORTIX INWARD TO MEDULLA, WHICH HAS URINE OSMOLALITY.

SEBBS AND DESERT ANIMALS CONCENTRATE URINE TO HIGH OSMOLALITY, THUS CONSERVING WATER TO THE POINT THAT SEBBS LIVE ON SUNFLOWER SEEDS WITHOUT DRINKING WATER.

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KIDNEY PROCESSES 15 L/day of fluid which is concentrated within distal tubules of kidney to urine. ^{ADH} DIURETIC HORMONE CONTROLS DEGREE OF CONCENTRATION. WATER REMOVED IN MEDULLA REGION IS CARRIED AWAY BY THE VASORECTA.

DISTRIBUTION OF WATER IN BODY COMPARTMENTS:

Body

IC	EC
25	15

40 liter

24 L. INTRACELLULAR

16 L. EXTRACELLULAR (of which 3 liter are BLOOD PLASMA)

WATER LOSS FROM BODY AS A WHOLE IS SHARED EQUALLY BY BLOOD PLASMA, ~~EXTRA~~ INTRACELLULAR H_2O , AND WATER-BINDING CELLS.

RETAINING TOO MUCH SALT CAUSES EXTRACELLULAR FLUID VOLUME TO INCREASE WHICH CAUSES HEART TO PUMP MORE - BAD.

ONLY MECHANISM FOR EXCRETING SODIUM IONS IS THROUGH URINE. SODIUM EXCRETION IS A FUNCTION ONLY OF VOLUME OF BODY FLUID.

MECHANISM OF SODIUM EXCRETION (NOT WELL UNDERSTOOD)

Juxtaglomerular Apparatus



→ AFFERENT ARTERIAL. CONTAINS A SECRETORY APPARATUS CALLED

CAUSES RENIN TO BE RELEASED IN EFFERENT ARTERIOLE WHICH RELEASES ANGIOTENSIN WHICH CAUSES ADRENAL CORTEX TO RELEASE ALDOSTERONE WHICH CAUSES NEFRON TO RELEASE SODIUM.

KIDNEY, WHEN FACED WITH CHOICE OF EXCRETING K OR Na , IT WILL EXCRETE K , ^{WATER} KIDNEY ALWAYS FUNCTIONS TO MAINTAIN ~~SODIUM~~ BALANCE, EVEN AT THE EXPENSE OF SODIUM CONCENTRATION GOING OUT OF BALANCE.

DISORDERS OF SODIUM BALANCE: DROPSY

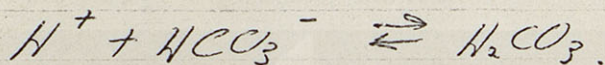
ADDISON'S DISEASE.

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ABNORMAL CO₂ AND O₂ TENSION: EFFECTS.

NORMAL H⁺ CONCENTRATION 35 to 45 nanomoles/litre
(pH 7.45) (pH 7.35)

~~FEASIBLE RANGE:~~

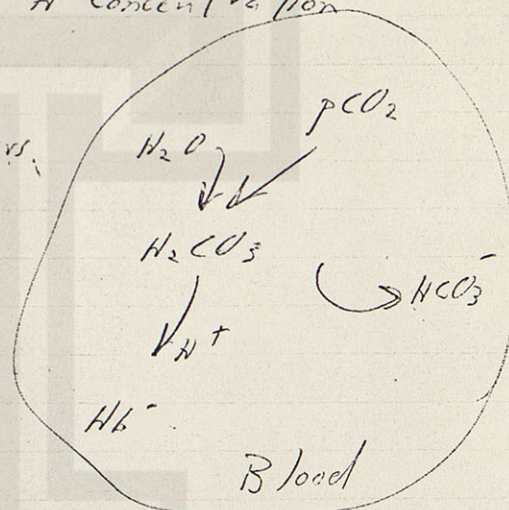


$$H^+ = K \frac{PCO_2}{HCO_3^-} \text{ equilibrium.}$$

40 mmHg = normal CO₂ partial pressure in body fluid.

Increase in PCO₂ increases H⁺ concentration

HCO₃⁻ (bicarbonate) is generated from body buffers.



Abscise doubling of PCO₂ from 40 to 80 mmHg, vs. H⁺ in H⁺ increase from a concentration of 40 to 60 nanomoles/litre.

IN HYPOXIA, A DROP IN BICARBONATE CONCENTRATION PROTECTS AGAINST DRASTIC REDUCTION IN H⁺ CONCENTRATION (as body HYPERVENTILATES, TAPERING OFF CO₂ RAPIDLY). THERE IS NOT ENOUGH PROTECTION TO REIN IN ALL EFFECTS.

WORKING PAPERS

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DONALD WEDON

MINERAL BALANCE

Physiological Considerations For Calcium

Calcium's main function is structural support of body through skeleton (Teeth?)

Other functions: coagulation of blood

Concentrations of Ca^{+} in blood for clotting must be within close limits 9. to 11. mg. %.

Balance of Calcium.

DIETARY INTAKE NORMALLY 500. to 800. mg/day.
Higher for young people, lower for older people.

1 quart of milk contains 1100 mg. of calcium.
12 qts/day of milk for teenagers not unusual.

Absorption of calcium from diet: 30% to 50%; average is about 35%.

Fecal calcium is ^{+ endogenous} unabsorbed intake; Fecal elimination is ~~only~~ elimination mechanism; plus urine.

50. to 200 mg. Ca. / day eliminated through urine.

Calcium is also a route of loss for calcium: 200. mg/day under conditions of profuse sweating. 15 ± 11 mg/day when no evident sweat while walking.

URINARY CALCIUM LEVEL IS RELATIVELY UNAFFECTED BY CHANGES IN (DIETARY) INTAKE.

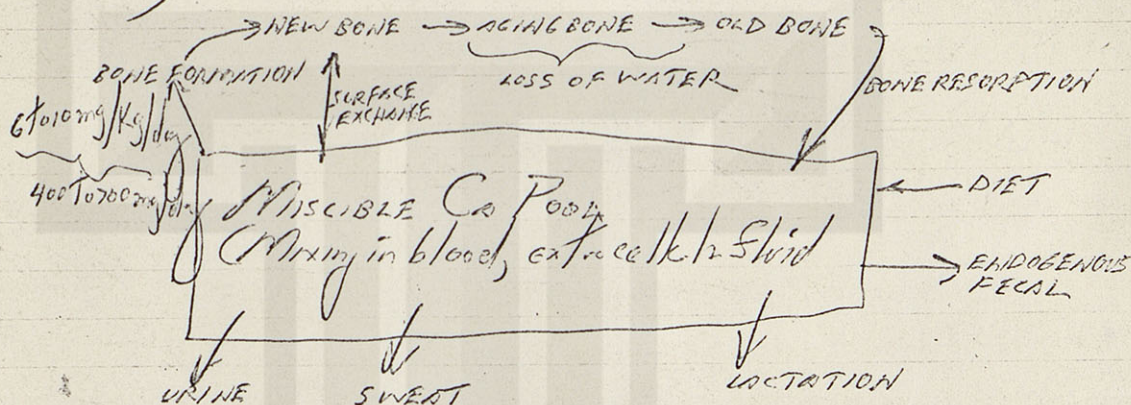
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INTAKE	OUTPUT
800 mg/day	520 UNABSORBED (Secal) 30 SWEAT 100 URINARY 450 endogenous Secl
	800 mg/day

Net balance here is zero.

Since 99% of Calcium is in skeleton, changes in Ca balance INDICATE SKELETAL CHANGES.

Bone is a dynamic tissue - it is not dead or inactive.



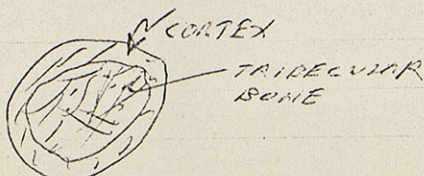
INTER-RELATIONSHIPS OF CALCIUM WITH ACID-BASE BALANCE

RATE OF ABSORPTION OF Ca CAN BE ENHANCED BY CHANGES IN ACID-BASE BALANCE.

AGE (YEARS)	
0 to 30	GROWTH OF SKELETON (ACCRETION)
30 to death	5% to 10% loss per decade - skeleton gets smaller.

MINERAL METABOLISM IN DISEASE: MANY DISEASES ASSOCIATED WITH EXCESS OR LACK OF CALCIUM ABSORPTION.

BONE CROSS-SECTION:



loss of bone density

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OSTEOPOROSIS: ULTIMATE EFFECT IS LOSS OF STRUCTURAL SUPPORT AND BONE FRACTURE.

→ CONCERN IN SPACE FLIGHT IS WHETHER BONE WILL MAINTAIN PROPER DENSITY, AND THEREFORE LOSS OF STRENGTH, IN ZERO-G.

Physical inactivity or immobilization can lead to osteoporosis
Bed-rest study: 1944-1946 CORNELL.

URINARY CALCIUM DOUBLES OVER NORMAL DURING BEDREST
FECAL CALCIUM ALSO GOES UP.

→ ANOTHER CONCERN: IF URINARY CALCIUM INCREASES TOO MUCH, CALCIUM PHOSPHATE MIGHT PRECIPITATE AS KIDNEY STONES, I.E. URINARY TRACT STONE FORMATION.

WATER IMMERSION: NO CHANGE DURING A ONE WEEK TEST; TOO SHORT A DURATION TO BE SIGNIFICANT.

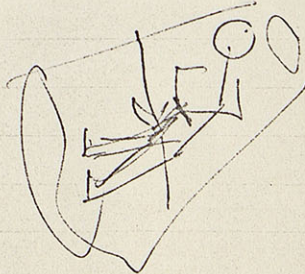
confined study to date

→ GEMINI 6, 7 14 DAY FLIGHT DEC. 1965:

ONLY METABOLIC TEST CONDUCTED IN DETAIL. RUSSIANS HAVE NOT DONE BONE DENSITOMETRY.

STUDY DONE WAS A METABOLIC BALANCE STUDY OF BORMANN & LOVELL FOR 10 DAYS, BEFORE FLIGHT, FLIGHT DURATION, AND 4 DAYS POST-FLIGHT.

A NONSTANDARDIZED (BUNGEE) EXERCISER WAS USED DURING FLIGHT.



IN RECENT BEDREST STUDIES, THERE IS SOME INDICATION OF A REDUCTION OF CALCIUM LOSS AFTER ~30 WEEKS, BUT NOT BACK TO BASELINE LEVEL. NO POSITIVE INDICATION THAT CA LOSS IS SELF-CORRECTING.

at equilibrium in bed rest.

Any evidence that bone density loss is self-limiting in bed rest study.

DIETARY CONTROL: GOOD PRE and POST FLIGHT, POOR IN FLIGHT.

→ ORBITAL INTAKE WAS LESS THAN PRE and POST FLIGHT INTAKES.

URINE SAMPLES FROM FLIGHT WERE NOT COMPLETE. (SOME SAMPLES BACKEN)

URINARY CREATININE IS ^{KNOWN TO BE} VERY CONSTANT ON EARTH; IN FLIGHT THE RAW DATA SHOWED VARIABILITY. RAW CALCIUM (URINE) DATA WAS CORRECTED FOR WHAT IT WOULD BE IF CREATININE WAS CONSTANT. CORRECTED URINARY CALCIUM DATA SHOWED TO RISE DURING FLIGHT.

FECAL CALCIUM DID NOT SHIFT MUCH FROM PRE-FLIGHT TO FLIGHT.

17-OH CORTICOSTEROID PRODUCTION WAS SHARPLY SUPPRESSED.

Results: modest calcium changes, definite phosphorus changes associated with loss of muscle tone.

Bed rest studies with polio patients shows greatest bone loss from lower extremities and skeleton. These are bones subjected to greatest stress differential in going to rest from activity.

WORKING PAPERS

WORKING PAPERS

BIOCHEMISTRY IN A WEIGHTLESS ENVIRONMENT: EDWARD KNOBLOCK

FOR A GIVEN INDIVIDUAL, HIS NORMAL BIOCHEMISTRY IS REMARKABLY STABLE.

ENVIRONMENTAL STRESSES IN SPACE THAT HAVE AN EFFECT ON BODY BIOCHEMISTRY:

WEIGHTLESSNESS

RADIATION

CONFINEMENT (SOCIAL RESTRICTIONS, MINORITY)

THREAT OF DANGER

ARTIFICIAL GRAVITY [Needed? Not good? Not detrimental?]

TOXIC MATERIALS

MICROBIOLOGY

CIRCADIAN RHYTHMS - STEROID, ADRENAL RESPONSES.

NOISE

THERMAL

INFRARED RADIATION

ULTRAVIOLET RADIATION

HUMAN BODY SYSTEMS IN WHICH ABNORMALITIES HAVE BEEN SEEN IN SPACEFLIGHT:

CARDIOVASCULAR SYSTEM

ABNORMALITIES HAVE BEEN OVERCOME THROUGH MAINTENANCE OF BODY FLUID VOLUME BY ENFORCED FLUID INTAKE. (PEOPLE IN SPACE HAVE A TENDENCY TO CONSUME LESS WATER THAN ON EARTH - THEY DON'T GET THIRSTY AS MUCH. NO ONE KNOWS WHY.

ENZYMES AND ISOENZYMES

PROTEIN

Monitor

% ISOENZYMES

% PROTEINS

indicates onset of disease.

- tells you state of hydration or dehydration of body measured by electrophoresis

Immunoelectrophoresis can be used to detect onset of infection by changes in immunoglobulins.

Lipoproteins - proteins composed of amino acids and lipids.

Study in progress to determine whether biochemical change in body can be used to predict onset of heart and liver malfunction.

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- NO SIGNIFICANT BODY BIOCHEMICAL CHANGES ARE TO BE EXPECTED IN FLIGHTS UP TO 30 DAYS.
- FOR FLIGHTS OVER 30-days duration it's important to monitor body biochemistry.
- FOR FLIGHTS OVER 90 days, biochemistry abnormalities may develop into serious problems.

LIVER
KIDNEY
MUSCLE
CARDIOVASCULAR
SKELETON

- MONITORING THAT IS DONE MUST BE DIRECTED TOWARD DETERMINING CHANGES IN BEHAVIOR OF BODY SYSTEMS.
- KNOBLOCH SUGGESTS INFILIGHT LOOKS AT URINE, SALIVA, RATHER THAN BLOOD WHEREVER POSSIBLE TO MINIMIZE VENOPUNCTURES OF CREW FOR BLOOD SAMPLES. THIS AREA NEEDS MORE WORK FOR LONG TERM APPLICATION.

ENERGY METABOLISM:

- CARBOHYDRATE METABOLISM: APPROACHING MOTION SICKNESS, PEOPLE WILL REDUCE PROTEIN INTAKE AND INCREASE CARBOHYDRATE^{AND LIPID (FAT)} INTAKE. SHOWN IN ROTATING ROOM AT PENSACOLA. ASTRONAUTS HAVE SHOWN REDUCED VOLUNTARY PROTEIN INTAKE IN FLIGHT.

TRACE METALS: PRINCIPAL NORMAL SOURCE IS TAP WATER. CHROMIUM^{IN BLOOD} IS KNOWN TO BE REQUIRED FOR NORMAL CARBOHYDRATE METABOLISM. (20 to 40 ppm in blood).

MOLYBDENUM IS REQUIRED IN FAT METABOLISM.
NICKEL MAY BE ESSENTIAL FOR PROTEIN SYNTHESIS.

NEW
FIELD
OF
BIOCHEMISTRY
OPENING UP
PICTURE
RECENT
AVAILABILITY
OF TRACE
ELEMENTS
TECHNIQUES

WORKING PAPERS

VITAMINS

A series of 50 factors, required for protein, lipid, and carbohydrate utilization.

NORMAL, NATURAL FOODS SHOULD PROVIDE ADEQUATE VITAMIN INTAKE.

→ IT TAKES ~~APPROXIMATE~~ 21 TO 30 DAYS TO DEMONSTRATE VITAMIN OR TRACE METAL DEFICIENCIES IN THE LABORATORY.

WORKING PAPERS

WALLACE JENSEN: HEMATOLOGY.
CIVIL, Dept. of Internal Medicine, GWU.

TALK WILL IGNORE WHITE CELLS, PLATELETS, MOST OF PLASMA.
CONCENTR. EMPHASIS WILL BE ON RED CELLS.

See printed notes.

MEAN RED CELL LIFESPAN IS 110. DAYS
 $\therefore$ they are renewed at $\approx 1\%$ /DAY.

CHROMIUM TECHNIQUE (^{ONLY ONE} USED IN SPACEFLIGHT SO FAR) IS NOT ACCURATE
A DIFFERENCE OF 30 DAYS IN MEAN LIFETIME WOULD NOT BE DETECTED
BY THIS METHOD.

RED CELLS HAVE A FINITE DISAPPEARANCE CURVE. (1% OF BLOOD
CELLS ARE 1 DAY OLD, 1% ARE 2 DAYS OLD, ... 1% ARE 100 DAYS OLD.)

APPROXIMATELY 1,000,000 RED CELLS/SECOND ARE MANUFACTURED
IN AN AVERAGE ^(70 KG) PERSON.

LEUKOCYTES AND PLATELETS HAVE A RANDOM STRUCTURE OF DISAPPEARANCE.

THE MARROW OF A NORMAL INDIVIDUAL CAN MAKE UP TO 2 TO 5 TIMES
THE NORMAL RATE OF RED BLOOD CELLS.
<sup>RED CELLS
PROLIFERATE</sup>

REGULATION OF RED CELL PRODUCTION: TISSUE OXYGEN TENSION
IS A MAJOR GOVERNING PARAMETER. Techniques for measurement
of cellular level do not exist.

ASTRONAUTS AT 5% pO_2 are hypoxic $\therefore$ they should get
downward cell production - ground tests show they do.

TISSUE hypoxia $\xrightarrow{\text{ERYTHROPOIETIN (EP)}}$ MARROW
 $\xrightarrow{\text{on } \alpha\text{-GLOBULIN}}$
CARRIES MESSAGE
FOR CONTROLLING
RED CELL PRODUCTION

WORKING PAPERS

~~THE~~ DESTRUCTION OF RED CELLS:

A 99 day old cell vs. a young cell is

smaller
has greater specific gravity
has lost water
" " lipids
has lost membrane enzymatic systems

HEMATOLOGICAL FINDINGS FROM MANNED SPACEFLIGHT:

OBSERVED LOSS OF PLASMA VOLUME WAS ANTICIPATED.

(400-500 ml of plasma is normal)

10% to 18% LOSS OF RED CELL MASS WAS OBSERVED IN GEMINI FLIGHTS

200 cc. of blood cell loss causes some loss of cardiovascular performance, but is not serious.

→ After 4th Gemini, Shatt: it was known that hemolysis occurred.

accelerated destruction of red cells must have occurred
why? Speculations:
Increased O₂ tension } chamber studies invalid in this.
Weightlessness
Acceleration-deceleration

No loss of red cell mass in immobilized bed rest study (Bodys);
but decreased red cell production rates.

Acceleration: some evidence of hemolysis in simulated Gemini g-profile of 5g return.

Hypothesis: Hypervoxia space Shatt may lead to condition cell reducing ability. How the stored g sources of re-entry.

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Apollo 7, 8 no evidence of Sved cell mass loss.
Some loss detected on Apollo 9.

→ THERE ^{IS} GROUND FOR DOUBT THAT LOSS OF RED BLOOD CELL MASS
IN GEMINI OCCURRED DURING ORBITAL BOOST BECAUSE OF
C. PROFILE LOSS OF RED CELL MASS AND LACK OF RED CELL MASS LOSS
IN APOLLO 7 & 8.

Jensen's opinion; Sved cell confused.

WORKING PAPERS

BRIGGS Phillips: Microbial Control (PHS)

AREAS OF TECHNOLOGICAL ADVANCEMENT:

RENTZ TECHNIQUE } ACCURATE SURFACE COUNTS
NEAR PLATING }

RODIC
SNABS

AIRWASHING
UV

particles
1 to 5 μ
in diameter

FILTRATION - MOST EFFICIENT, USUALLY MOST PRACTICAL.
FILTERS ARE BETTER THAN ELECTROSTATIC PRECIPITATORS
(99% REMOVAL) (90% REMOVAL)

Highest Efficiency Filters: 99.9% removal.

AIR FILTRATION OF MICROBIAL PARTICLES,
U.S. P.H.S. MONOGRAPH.

DECONTAMINATION MECHANISMS:

- HEAT
- GASES - Ethylene Oxide (non-corrosive) *very good, efficient.*
- LIQUIDS
- RADIATION - UV
- PHYSICAL REMOVAL (FILTRATION)

MICROBIAL BARRIERS:

LAMINAR AIR FLOW

20 to 30 ft/min: 2 low speed for laminar flow - the wind gradients and other effects cause turbulence.

At about 100 ft/min, any object placed in laminar flow will trail a dead spot 3 diameters down stream.

CONTAMINANTS: GASEOUS
PARTICULATE (SOLID AND LIQUID)

SOURCES OF S/C CONTAMINATION:

SUPPORT EQUIPMENT

THERMAL DEGRADATION

OFF-GASING

LEAKS

OCCUPANTS - ~~St. Tulace~~

INTERACTIONS IN ATMOSPHERE

WASTE DISPOSAL

PROPELLANTS

e.g. CO and $\text{O}_2 \rightarrow \text{CO}_2$; $\text{Sulfur} \rightarrow \text{SO}_2$.

SOURCES OF TOXIC MATERIALS:

PAINTS

ADHESIVES

INSULATION

SEALS AND SEALANTS

POTTING COMPOUNDS

COATINGS

NUCLEANTS

(ODDLY ENOUGH, MAN IS A GOOD CONVERTER OF TRASH BURNERS HIMSELF)
~~HEALTH CARE~~

CONTAMINANT REDUCTION IN S/C:

1. CONVERSION (CAT. BURNER)
2. DILUTION [LIMITED APPLICABILITY IN CONFINED S/C]
3. LEAK TO SPACE
4. DISPOSAL (LION/CARBON pull/puff out of Ejector)
5. MON (Acts as a garbage collector and concentrator)

WORKING PAPERS

SUBSURFACE, TERRESTRIAL CONDITIONS NOT COMFORTABLE TO S/C
SINCE S/C CAN'T GET AWAY FROM CONTAMINANTS.

↑ BUT CAN BLOW-DOWN S/C TO FLUSH OUT CONTAMINANTS.

AT KSC, lost soil, blew down S/C in attitude chamber,
cleaned it out, but an hour later contaminant levels
were back up (due to outgassing).

LIMITS ON CONTAMINANTS:

MAC = MAXIMUM ACCEPTABLE CONCENTRATION ^{no applicability in S/C. because}
TLV = THRESHOLD LIMIT VALUE ^{8 hrs/day 5 days/wk.} of continuous exposure.

RESPONSES TO CONTAMINANTS:

1. NONE MEASURABLE
2. DISCOMFORT
3. ALTERATION IN PERFORMANCE
4. REVERSIBLE PATHOLOGICAL CHANGES
5. IRREVERSIBLE
6. DEATH.

RUSSIAN APPROACH: ACCEPT NO MEASURABLE CHANGE IN MAN (PHYSIOLOGICAL,
BIOCHEMICAL, PSYCHOLOGICAL) AND SET ACCEPTABLE LIMITS AT
 $\frac{1}{6}$ THE LEVEL AT WHICH DETECTABLE CHANGES OCCUR.

FACTORS AFFECTING RESPONSE

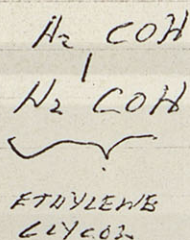
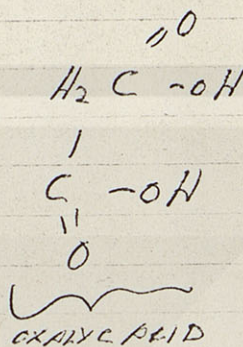
GASEOUS ENVIRONMENT
TEMPERATURE
EXPOSURE DURATION
PRESSURE
LEVEL OF FATIGUE
INTERACTIONS OF ABOVE FACTORS
DEGREE OF MAN'S MOBILITY

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HISTORICAL EVENTS:

"PRESTONE" ANTIFREEZE

ETHYLENE GLYCOL SPILLAGE FROM COOLANT LOOP JOINTS IN CABIN 1


 OXIDIZED
 30
 WITHIN
 BODY


↑ could have very effects

EXPOSURE OF MAN TO VAPOR: NO RESPONSE AT LEVEL BELOW WHICH CREW COULD DETECT IT

NO RESPONSE AT LEVEL AT WHICH MAN CAN DETECT IT BY BITTER TASTE IN MOUTH.

NO INDICATIONS YET OF TOXIC SUBSTANCES IN S/C CHARCOAL CANISTERS.

WORKING PAPERS

HERMAN SCHAEFER - SPACE RADIATION AND MAGNETIC FIELD ENVIRONMENTS

TYPICAL RADIATION LEVELS ON EARTH

LOCATION	MICORADS/HR	MILLIRADS/YR
MID ATLANTIC	6	55
N.Y.C. CITY	8-15	70-130
TRAVANCORE, INDIA	900.	8,000.
GUARAPARI (BEACH, INDIA)	2,000.	17,500

RAD = ROENTGEN ABSORBED DOSE

REME = " EQUIVALENT MAN

RAD X INTENSIFYING FACTOR = REM
(DEPENDS ON WAVELENGTH)

SPERM COUNT IN DOGS IS ALTERED BY AS LITTLE AS A 5. RAD DOSE.

SIGNIFICANCE OF DOSES OVER LONG TERM IS NOT YET KNOWN.

RADIATION
LEVELS
OF SPACE
AND
COMPARISONS

	MILLIREM/HR
GAALACTIC RADIATION	1. to 10.
RADIATION BELT	1. to 1,000.
SOLAR PROTONS	1. to 10^6 & FLARES - VERY RARE AT 10^6 MILLIREM/HR (7 EVENTS AT THIS LEVEL RECORDED IN 20. YEARS)
SEA LEVEL BACKGROUND	10^{-2} to 1.
ICRP RECOMMENDATION	10^{-1} to 1.

FLARE RADIATION (PROTONS) IS SOFT - HAS RELATIVELY LOW PENETRATING POWER
GAALACTIC RADIATION: HARD - VERY PENETRATING; CAN'T SHIELD AGAINST
GAALACTIC RADIATION. SHIELDING INCREASES DOSEAGE THROUGH SECONDARY
RADIATION.

SOLAR WIND: IONIZED HYDROGEN FROM SUN ^{CONTINUALLY} STREAMING OUTWARD

BASIC CHARACTERISTICS OF SOLAR WIND:

- SOLAR WIND EXISTS DURING "BOTH QUIET AND ACTIVE SUN"
- 300 KM/SEC SPEED, BUT GUSTY "UP TO 800 KM/SEC MAX"
- (SPEED CHANGE BY A FACTOR OF 5 IN A FEW HOURS).
- AS SPEED INCREASES, DENSITY DECREASES.
- SOLAR WIND IS NEUTRAL (CONTAINS BOTH ELECTRONS & PROTONS)
- HIGHEST DENSITY + PROTONS

WORKING PAPERS

SPEED OF SOLAR WIND DOES NOT CHANGE BETWEEN 1. AND 0.7 A.U. (MARINER VENUS DATA) - density did change.

Thermodynamics
 Temperature of solar wind is measured from coordinates moving locally from with average solar wind velocity:
 6,000 °K to 900,000 °K } Range.

Magnetic Fields associated with solar wind: quite small.

Typical
 Magnetic
 Field

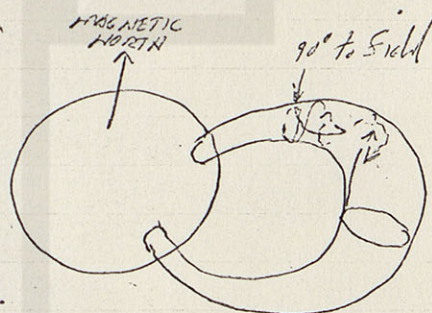
{ @ Earth's surface 0.2 gauss.
 in solar wind 1. to 5. $\times 10^{-5}$ gauss

1 gauss = 10^{-5} T

That small in intensity, it is large in extent over space and therefore significant in solar galactic radiation.

MAGNETIC TRAPPING IN
 EARTH'S MAGNETIC FIELD:

Particle travels in spiral until its plane is normal to field, it then reverses and spirals along tube again.



JOHNSTON ISLAND
 NUCLEAR EFFECT
 (1957)

ARTIFICIAL
 AURORA

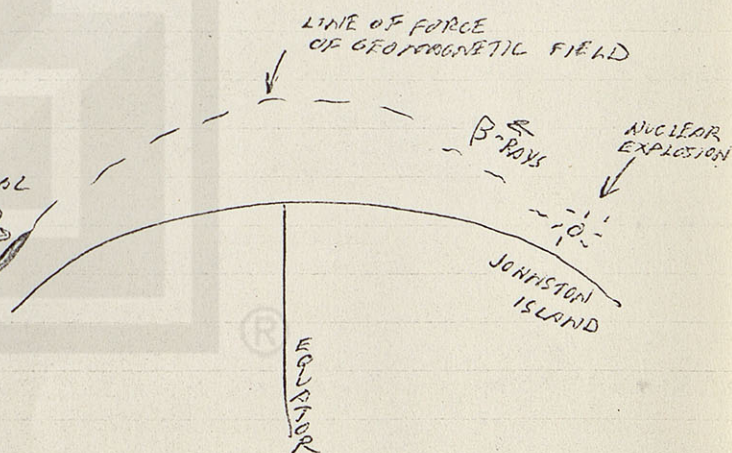
LINE OF FORCE
 OF GEOMAGNETIC FIELD

B-RAYS

NUCLEAR
 EXPLOSION

JOHNSTON
 ISLAND

EQUATOR



WHAT CAUSES S.A. ANOMALY?

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SOUTH ATLANTIC ANOMALY: TRAPPED PROTONS

95% OF ASTRONAUT EXPOSURE IN LOW EARTH ORBIT
COMES FROM 2-10 MINUTE PASSES THROUGH S-A. ANOMALY.

FLARES ARE ALWAYS ASSOCIATED WITH SUNSPOTS, BUT NOT ALL
SUNSPOT GROUPS PRODUCE FLARES. ONCE A SPOT GROUP HAS
PRODUCED A FLARE, A RE-OCCURENCE OF A FLARE IS VERY LIKELY.

10% PROBABILITY 5 RAD DOSE ON 30 DAY MISSION DURING ^{PIC} ^{CYCLE} 30 MAX FLARE 19.

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RADIATION BIOLOGY: WRIGHT LONGHAM

FOR BIG REFERENCE: SEE REF. 3 ON P. 21-6 OF THE PRINTED NOTES.

all of this lecture is in

NAS/NRC 1,487
PUBLICATION

SEE ALSO AUG. SEPT. 1969 AEROSPACE MEDICINE,
ARTICLE BY WRIGHT LONGHAM.

1895 - ROENTGEN DISCOVERED X-RAYS.

DEC. 3, 1942 - FERMI'S FIRST SELF-SUSTAINED NUCLEAR REACTION.

MAXIMUM PERMISSIBLE LEVELS APPROPRIATE TO INDUSTRIAL
WORKERS MAY BE OVERLY RESTRICTIVE WHEN APPLIED TO
SPECIALISTS IN SPECIFIC OPERATIONS SUCH AS SPACEFLIGHT.

NAS/NRC STUDY PANEL: HERMAN SCHAEFER - PHYSICIST WHO SUPPLIED

QUANTITATIVE
DESCRIPTION OF
ENVIRONMENT.

WRIGHT LONGHAM - ORGANIZED AND APPROVED IT.

GALACTIC COSMIC RAYS: VERY LOCALIZED DEATH OF CELLS: HOW SIGNIFICANT?
↓ MEN ON LONG SPACE MISSION WILL LOSE BRAIN CELLS
(WHICH ARE NOT REGENERATED) - HOW SIGNIFICANT?

RADIATION EFFECTS:

1. SOMATIC EFFECTS

A. EARLY OR ACUTE MANIFESTATIONS

1. INITIAL REACTION
2. ACUTE SKIN REACTION
3. HEMATOPOIETIC DEPRESSION
4. EARLY LETALITY
5. STERILITY

B. LATE OR CHRONIC MANIFESTATION

1. ACTUARIAL LIFE SHORTENING.

INTERIM PROPOSAL - COMMISSION ON
NCRP-ICRP RECOMMENDATION FOR

WORKER'S AGE



Maximum Permissible Exposure Level $\equiv 5 (N-18)$ REMS
FOR INDUSTRIAL WORKERS

i.e. 5 REMS/YR.

PROTON
INTEGRATED DOSES THAT WOULD HAVE BEEN EXPERIENCED IN A 10 DAY LUNAR
MISSION DURING THE
TRIPLE "BIG FLARE"
OCCURRENCE OF JULY 1959.

{ 400 RADS with $2g/cm^2$ shielding
100 RADS " $5g/cm^2$ " }

BASED ON
ONE SHOT
X-RAY
DOSES

{ 50% OF PEOPLE WOULD EXPERIENCE ERYTHEMA IF EXPOSED TO
600 RAD AT BASAL LAYER OF SKIN.

→ (95% AT 800 RAD)

{ 50% OF PEOPLE WOULD EXPERIENCE MOIST DESQUAMATION IF
EXPOSED TO 2,000 RADS AT THE BASAL LAYER OF SKIN.

→ (95% AT 2700 RADS)

HOWEVER, DOSES ARE GIVEN IN EQUAL DAILY AMOUNTS,

[DURING 30 DAYS, ERYTHEMA OCCURS AT 120 RADS TOTAL][?]

PRODRGICAL
SYNDROME

SEVERITY OF RESPONSE TO SINGLE ACUTE RADIATION:

ANOREXIA

NAUSEA

FATIGUE

VOMITING

DIARRHEA

DEATH

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BIOLOGICAL
BLOOD COUNTS ARE NOT A GOOD [^]RADIATION DOSEMETER.

WHOLE BODY
^
285
50% OF NORMAL PEOPLE WILL DIE IF EXPOSED TO ~~500~~ RADS
ACUTE RADIATION.
X-RAY
↓
MEASURED AT
MID-LINE OF BODY.

ATAGONIA
SPERM ~~CELLS~~ ARE MOST SENSITIVE CELLS IN BODY, TO RADIATION.

DATA ON A LARGE
NUMBER OF
PRISON VOLUNTEER
SUBJECTS.

{ SPERM COUNTS DROPPED TO 30% OF NORMAL AFTER 60 DAYS
AND STAYED AT THAT LEVEL FOR 185 DAYS
Tend of
data

CATARACTS:

AFTER 50 DAYS 400 RADS WILL NOT PRODUCE CATARACTS
" " " 1,050 RADS WILL PRODUCE CATARACTS

STATISTICAL LIFE SHORTENING: 10 DAYS/RAD FOR 2.50 RAD/DAY EXPOSURE
1 DAY/RAD FOR 1 RAD/DAY "

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RADIATION PROTECTION: DIET MOELLER

NATURAL BACKGROUND RADIATION INCREASES WITH ALTITUDE AND WITH GEOGRAPHIC LATITUDE.



LET X-RAYS PASS THROUGH AIR UNTIL 2 BILLION ION PAIRS/ cm^3 HAVE BEEN FORMED; IT IS THEN SAID THAT ^A1 ROENTGEN DOSE HAS BEEN RECEIVED BY THE AIR.

PUT YOUR HAND IN PLACE OF AIR, AND IT IS SAID YOUR HAND HAS RECEIVED ^A1 RAD DOSE [?].
1 per cm^2 .

RBE = Relative Biological Effectiveness.

SHIELDING: AS A BEAM PASSES THROUGH SHIELDING, LOWER ENERGY PARTICLES ARE ABSORBED PROGRESSIVELY.

X-RAYS ARE PRODUCED COMMERCIALY BY DIRECTING AN ELECTRON STREAM AT A TARGET (X-RAY TUBE). THIS SECONDARY RADIATION IS BREMSTRAHLUNG.

" "

THE ^Z NUMBER (NO. OF PROTONS IN NUCLEUS OF ELEMENT) OF TARGET MATERIAL DETERMINES EFFICIENCY OF BREMSTRAHLUNG PRODUCTION. $\therefore$ LIGHTER MATERIALS ARE BETTER THAN HEAVY ONES SUCH AS LEAD TO KEEP BREMSTRAHLUNG DOWN.

GALACTIC RADIATION: INNER RADIATION BELT OUTER RADIATION BELT

PROTONS
ALPHA PARTICLES
HEAVIER NUCLEI
ELECTRONS

85% 10^8 to 10^{10} eV
14% 2.5 particles/ cm^2/sec
1% DOSE = 10 REM/YEAR
RECD.

10^6 to 10^9 eV
 10^4 to 10^6 eV
2.5 REM/Hr
2000 REM/Yr
 10^5 to 10^6 eV
 10^4 to 10^7 eV

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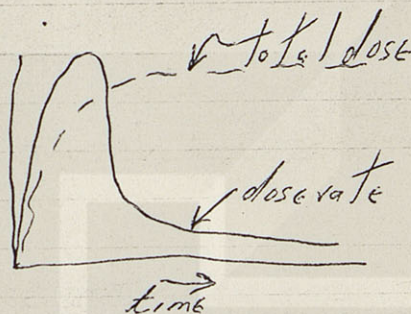
54

100 e.v.g.s/GRAM ABSORBED ENERGY $\equiv$ 1 RAD

IF RBE IS ONE, 1 RAD IS EQUIVALENT TO 1 REM

1 REM $\equiv$ 1 RAD $\times$ RBE of radiation

SOLAR FLARE



Monitoring radio emissions from sun can give two hours warning of solar flares.

CURRENT PERMISSIBLE DOSES WHOLE BODY DOSES

	AVERAGE	EMERGENCY
WORKERS	5 REM/YR	25 REM/YR
POPULATION	0.5 "	15. " "
INDIVIDUALS	(5 REM/50 YRS)	(5 REM/50 YRS)
GENEVA		
ASTRONAUTS	55. REM/YR	200. REM/YR

See also next page for more limits on solar flares

SOLAR FLARES 1000 to 3000 REM/HR ^{max}

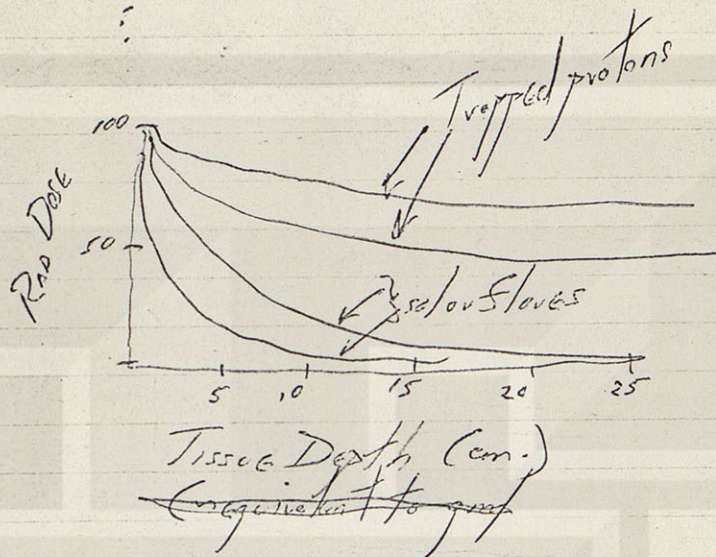
PROTONS } 10^6 to 10^{10} eV } 10^9 to 10^{12} particles/cm²/sec
NEUTRONS }

500 to 2000 REM/HR (TOTAL)

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RISK ANALYSIS : MINIMIZE DOSE
DONT JEOPARDIZE CREW

Depth Dose:



$$2 \text{ #/5t}^2 \approx 19 \text{ m/cm}^2$$

PERMISSIBLE DOSES (ASTRONAUTS)

ORGAN	ANNUAL	EMERGENCY (ONE EVENT)	TOTAL
BLOOD FORMING	55 rem/yr	200 rem/yr	270 rem
SKIN	350. " "	700 " "	1600 "
EXTREMITIES	770. " "	980. " "	4000. "
EYES	55. " "	200. " "	270. "

APOLLO MONITORING:

1. PARTICLE MONITORING SYSTEM - Solid state detectors
~~2.~~ (HEAVY PARTICLES, proton, alpha particles)
 Sandwich detectors give flux and energy distribution.
2. VAN ALLEN BETT dosimeter,
 [100cm³ - tissue equivalent dosimeters]
4. PERSONAL RADIATION DOSIMETER - PORTABLE
5. PASSIVE DOSIMETERS - FILM, DATA AVAILABLE ONLY AFTER CREW RETURNS.

ALSO
RADIATION SURVEY
DOSIMETERS →

POSSIBLE ASTRONAUT PROTECTION MECHANISMS:

- SHIELDING - PHYSICAL
- ELECTRICAL { ELECTROSTATIC
ELECTROMAGNETIC
- OPERATIONAL - FLIGHT PATH
- TRIP TIMING
- CAPSULE ARRANGEMENTS (i.e. shielding)

disturbance: plasma shield, vesicularity in
progress on feasibility of
this.
10² VOLTS, 10² KW to maintain this charge

FLARE EVENTS BY MONTH: MOST COMMONLY OCCUR IN JULY
 Occurrence peaks here!

SHIELDING PROBLEMS

LOW ORBITAL FLIGHTS: NO PROBLEM
 PROTONS (> 1 BeV) - NO HOPE of Shielding
 PROTONS () (MAJOR PROBLEM)

SHIELDING

1. LOW Z MATERIALS to minimize Bremsstrahlung
2. INNER LINER FOR X-RAYS (shield from Bremsstrahlung)
3. "STORM CELLAR"

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→ SPACE STATION: INCLINATION IS SIGNIFICANT; high latitudes expose you to SLOVE VISK.

DRUG PROTECTION FROM RADIATION; LOTS OF MONEY SPENT, NO RESULTS YET.
MONEY MAN TO MINIMIZE SENSITIVITY TO RADIATION; SCIENCE FICTION.

SELECTIVE SHIELDING; SHIELD NEUTROPHILIC ORGANS (BONE MARROW)
PELVIC REGION IN MAN IS MAIN REGION, BUT MARROW IS ALL OVER, ESPECIALLY IN JOINTS.

→ Storm cellar or spcovenation is best solution.

Radiation kills at the cellular level by ionizing which upsets its biochemistry.

The origin of S dipole field of Earth; ^{best} hypothesis of moment is rotating liquid core.

→ Cause of South Atlantic Anomaly is not known.

EARLIEST FLORE EVENT REPORTED WAS IN 1845. SUNSPOTS COUNTS HAVE BEEN ACCURATELY REPORTED SINCE THE LATE 18th CENTURY.
we have good data on the present and preceding solar cycles only.

No statistical validity { Studies on monkeys at several radiation doses up to lethal doses showed no performance decrement on difficult to perform pilot-like tasks [push lighted button; respond to bell to avoid electric shock].

DATA FROM APOLLO LUNAR MISSIONS:

Apollo 16	VIII	220 MILLIRADS	} VARIATION DUE TO INCLINATION AT WHICH RADIATION BELTS WERE CROSSED.
"	X	500	
"	XI	~350 ↑ COLLIMATOR	

WORKING PAPERS

MAGNETIC FIELDS

PHYSIOLOGICAL EFFECTS OF ~~LOW~~ FIELDS: MRS. HENRIETTA CALVERT

QUANTITATIVE $\Rightarrow$ EXPERIMENTS ONLY BEGUN IN LAST 10 YEARS.
NO EXPLANATION OF MECHANISM

INTERPLANETARY
SPACE OUTSIDE EARTH

INTENSITY
LOW FIELD EFFECTS 10 to 100. $\times$ 1×10^{-5} OERSTEDS

HIGH INTENSITY FIELDS 100 to 1000 OERSTEDS

HALPERN, & VANDYKE: expts. on mice exposed to 100 $\times$ field. For 4 to 12 MONTHS.

FIRST GENERATION APPEARED NORMAL
20% OF SECOND GENERATION EXHIBITED SHORTER LIFETIMES,
CYSTS IN MOST ORGANS, EXCESSIVE LOSS OF HAIR.
IN GENERAL, THESE MICE EXHIBITED ACCELERATED AGING.

HALPERN, & GREEN: HAMSTER EMBRYO CELLS - decreased aging effects.

Other animal expts. showed no effects.

No debilitating effects of 100 $\times$ exposures in men in working environment. Based on interview only.

No changes in low field (50 $\times$) expts. on men except in "Flicker Fusion Frequency".

Not due to confinement alone.

decrease in visual acuity; eyes would have a constant sensation of brightness.



Removal of Magnetic Field may result in synthesis of defective protein in body (hypothesized explanation).

LOW INTENSITY FIELDS

INDUCED ACTIVITY (CREATION OF RADIOACTIVE MATERIAL IN MAN):

{ Neutron bombardment produces radioactive Sodium.
 { Proton bombardment produces radioactive Beryllium.
 But these are inconsequential effects compared with the effects of direct exposure.

SUPERSONIC TRANSPORT DOSES that will be received:

SOURCE	ALTITUDE (ft.)	DOSE RATE (per hour)	TOTAL DOSE (REMS)
GALACTIC	80,000	2. to 3. mrem	1 to 2 per year
SOLAR FLARES	80,000	1. to 10 rem	~ 4 per event
	40,000	10. to 100 mrem	~ .04 per event

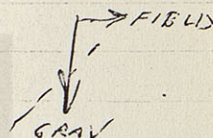
DISCUSSION (Comment not those of speaker above)

The "11 year solar cycle" actual varies from 10. to 13 years; mean is 11 years.

Dose + ^{protons}
 200 millihours during 8 day Apollo 7 mission
 95% from South Atlantic Anomaly.

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HIGH INTENSITY MAGNETIC FIELDS: A MAGNETIC FIELD OF
A FEW THOUSAND OERSTEDS IN MICE CAUSED REJECTION
OF CANCER CELLS; POSSIBLE VESTIBULAR EFFECTS; MICE



MICE "LEANED" 20°
OFF VERTICAL.

→
MAUSE OTOLITH
MAY HAVE SIGNIFICANT
MAGNETIC PERMEABILITY

EXPTS. THUS FAR ARE
POORLY, SKETCHILY REPORTED.

DISTURBANCES IN NERVOUS SYSTEM OF ANIMALS NOTED BY EXPOSING
ONLY BRAIN TO MAGNETIC FIELDS.

90,000 OERSTEDS FOR 24 HRS.
CHANGE IN HEART RATE
RESULTS
(DISTORTION OF QRS
WAVE IN EKG)
NO CHANGE SEEN WITH 90,000 OERSTEDS
FOR 15 MINUTES.

ANOTHER STUDY SHOWED A PHASE SHIFT
IN EEG (POSSIBLY EXPT. ERROR)
(ONE EXPT. SHOWED SHIFT IN DIRECTION OF
HIGHER FREQUENCIES; ANOTHER EXPT. SHOWED SHIFT IN
OPPOSITE DIRECTION.)

KHOLODOV
100. to 200. OERSTEDS → showed inhibition of behavior (B)

SAME EFFECT GOTTEN BY EXPOSING BRAIN ONLY AND WHOLE BODY;
∴ EFFECT MAY BE ALL IN BRAIN.

Expt 500 Rabbits & Cats For 1. to 70. HOURS @ 100. OERSTEDS

AFTER 1. HOUR, THE GLIA HAVE ARE SWOLLEN AND DIVIDING
AT A HIGHER RATE THAN NORMAL.
NO CHANGE IN NEURONS.

AFTER 10 TO 12 HOURS, NECROSIS OF GLIA OCCURS

AFTER 70. HOURS, NECROSIS OF GLIA AND NEURONS WAS
OBSERVED.

[IF MAN WERE IN SPACE WITH PROSTHA SHIELD @ 100 OERSTEDS, HE MIGHT EXHIBIT NECROSIS OF NEURONS]

HUMAN EXPOSURES TO HIGH INTENSITY FIELDS:

NO DELIBERATE EXPTS. KNOWN.

REVIEW OF ACCIDENTAL EXPOSURES AND REGULAR INDUSTRIAL EXPOSURES REVEAL NO GROSS ILL EFFECTS, EITHER PHYSIOLOGICAL OR PERFORMANCE.

PUTTING 1000.0ERSTEDS ACROSS HEAD
RESULTS IN FLASHING LIGHT SENSATION TO
SUBJECT.



NOT OBSERVED WITH FIELD
ORIENTED
THIS WAY.



DAILY VARIATION OF
EARTH'S MAGNETIC
FIELD IS THIS GREAT

ROCARD (1964)

"HUMAN DOUSERS" WERE WALKED THROUGH 0.3 ~~mi.~~ mi./100ERSTEDS/m

UNTRAINED
ANY PERSONS

EFFECT IS UNCONTROLLED
INHIBITION OF MUSCLE
CONTRACTION.

FIELD AND COULD
ALWAYS DETECT
PRESENCE OR ABSENCE
OF FIELD.



SAME QUALITATIVE FIELDS DETECTED WITH D.C. AND A.C. FIELDS.

Propose exp. to detect field effects

PHYSIOLOGICAL EFFECTS OF LIGHT ENERGIES : DR. FERRIS

See printed notes.

EFFECTS OF UV:

photosensitization per some "SHALIMAR" WILL DOE THIS.
 eckey pickers & dermatitis
 pigmentation } normal response to UV for protection.
 thickening of skin

UV causes pro-melanin to convert to melanin in skin.

UV is not very penetrating, even at high intensities.

Snow blindness outer edge of cornea sloughs off.

cumulative effect

CARCINOGENIC EFFECTS: continuous exposure to sun causes skin cancer.

UV is not felt by man during exposure.

germicidal effects: limited usefulness because of low penetrability
 (germs inside a dirt particle may survive)

Visible spectrum 4,000 to 8,000 (one octave)
 glare

LOOKING AT SUN DIRECTLY CAUSES VISIBLE LIGHT TO FOCUS ON THE MACULA (PORTION OF RETINA USED FOR PRECISE VISION); CAN CAUSE PERMANENT RETINAL DAMAGE. THIS IS NOT A UV EFFECT, SINCE UV IS NOT VERY PENETRATING - WON'T EVEN PENETRATE TO THE LENS OF THE EYE.

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INFRARED

SHORT INFRARED
LONG INFRARED

move power & heating effect than long in IR

IR penetrates to ~~the~~ inner layer of skin.

Every object above 0°K radiates in IR.

Action of IR is only a heating phenomenon.

IR radiation will produce cataracts in eyes because eyes have poor heat rejection mechanism.

Protection from IR: shiny reflectors, insulation, active convective cooling.
Special glasses (IR opaque)

MICROWAVES

INSTANTANEOUS EFFECTS: sensed quickly because they don't penetrate body deeply.

DELAYED EFFECTS - DIATHERMY - LONG WAVE: HEATS CORE OF BODY BUT IS NOT FELT BECAUSE THERMAL SENSORS ARE ON SURFACE OF BODY.
- MICROWAVE COOKING

Microwaves act on tissue only as a heating effect.

SAFE LEVELS:

10 MILLIWATTS/cm² - ALLOWABLE MICROWAVE ENERGY FOR WORKERS (8 HRS/DAY)

1. MILLIWATT/cm² - ALLOWABLE CONTINUOUS EXPOSURE FOR GENERAL POPULATION.

DR. LAVERY: UTILIZATION OF ELECTROMAGNETIC ENERGIES IN BIOMEDICAL INSTRUMENTATION

1. TELEMETRY
2. REMOTE SENSING:
 - a) SPATIAL
 - b) SPECTRAL
 - c) TEMPORAL

PULSE AMPLITUDE MODULATION:

SAMPLE ANALOG SIGNAL

TRANSMIT DISCRETE SAMPLED INFORMATION

OCULOMETER: MEASURE EYE POINTING
 USE EYE-POINTING FOR
 CONTROL SIGNAL.

$60^\circ/\text{sec.}$
 $\frac{1}{3}^\circ$ } eye can track to within $\frac{1}{3}^\circ$ at $60^\circ/\text{sec.}$

Spectro: look into eye - spectra of light reflection indicates
 "color" quantitatively, which can be correlated
 with degree of oxygenation of retinal blood.

T 003

Amplitude of energy detected is $\propto \sin^2 \theta$ of particle size.

JOHN
COL. STAPP, NAT. HIGHWAY SAFETY BOARD ACCELERATION

WORKING PAPERS

$$J_{OCT} = \frac{d \text{ acceleration}}{dt} = \frac{d^3 x}{dt^3}$$

After rapid whole body acceleration ("impact"), heart rate slows for 10 to 30 seconds, then returns to normal.

Reaction of most subjects to 20g deceleration (0.16 seconds duration) is anxiety. This typically disappears after repeat runs.

SOURCES OF DATA ON HUMAN RESPONSE TO IMPACT:

OBSERVATION OF AUTO ACCIDENT EFFECTS

FREE FALLS TO EARTH, WATER, SNOW

EXPERIMENTS

HUGH DELHAVEN: DID PIONEERING WORK ON EFFECTS OF FREE FALL EFFECTS ON HUMANS.

(1942)

54 ft free stopping distance 4" (packed golden earth)

140 g.

left side and back

conscious, not injured.

IF YOU FALL FROM A GREAT HEIGHT, 1) LAND FLAT ON YOUR BACK IF ON LAND.
2) LAND VERTICALLY, IF ON WATER.

SNYDER: COLLECTED DATA ON 18,000 HUMAN FREE FALLS, INCLUDING 7,000 FATAL FALLS.

~~FROM INJURY~~

Falls into snow have been recorded from terminal velocity (482' high or greater, 121 mph) with no injury or loss of consciousness.
at sea level.

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A. Edwards AF Base)

DURING 1947-1951 215 expts. with humans, chimpanzees, and orthopaedic
↑
13 subjects dummies

13 subjects

142 f 0.206 #

25 to 39 yrs old

(total 0.554
expts.)

STOPPING DISTANCE FOR 20g deceleration $\frac{v^2}{2a}$ FROM VARIOUS SPEEDS

mph

DISTANCE (57 inches)

fc.

10:30"

120

23' - 4 1/2'

160

44'-2"

200

WORKING PAPERS

HEINING VON GIERKE: BIODYNAMICS, VIBRATION, AND NOISE

Has done much to NASA's supporting research in this area.

TYPE OF EXCITATION	SIMULATION DEVICE
STATIC PRESSURE	CHAMBER
TRANSIENT PRESSURE	BLAST TUBE CHAMBER
ACOUSTIC "	NOISE CHAMBER
SUSTAINED ACCELERATION	CENTRIFUGE
TRANSIENT "	SLIDS, DROP TOWERS
LINEAR VIBRATION	SHAKE TABLES
SPIN	SPIN TABLES
TRANSIENT SPIN	" "

DEFORMATION OF BODY TISSUE AND ITS EFFECT ON ORGAN FUNCTIONS:

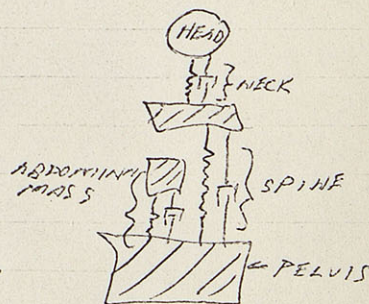
PHYSICAL
PHYSIOLOGICAL
PSYCHOLOGICAL

→ A COMPRESSION FORCE APPLIED TO THE BODY IS PROPAGATED NOT AS A COMPRESSION WAVE, BUT AS A SHEAR WAVE FOR FREQUENCIES UP TO 1 MEGACYCLE.

→ BREAKING STRENGTH OF MONKEY BONES WAS REDUCED 50% AFTER 60 DAY IMMOBILIZATION.

$$\frac{\text{APPLIED FORCE}}{\text{RESULTING VELOCITY}} = \text{IMPEDANCE}$$

$\frac{\text{spinal mass}}{\text{frequency}} = \frac{S_{\text{man}}}{8. \text{ cps.}}$
 $\frac{\text{Abdominal mass}}{\text{frequency}} = 4. \text{ to } 8. \text{ cps.}$
 $\frac{\text{chest wall}}{\text{frequency}} = 60. \text{ cps.}$
 $\frac{\text{Head}}{\text{frequency}} = 30. \text{ cps}$



WORKING PAPERS

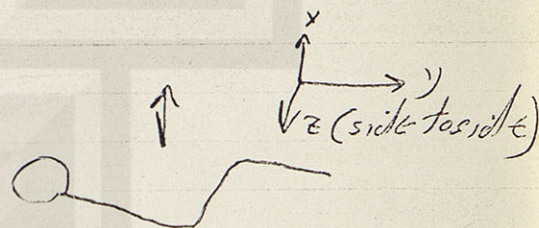
CHEST RESONANT FREQUENCY IS ~~NOT~~ PROPORTIONAL
TO THE CUBE ROOT OF BODY WEIGHT

↑
BASED ON TESTS OF MOUSE, RABBIT, DOG, MAN.

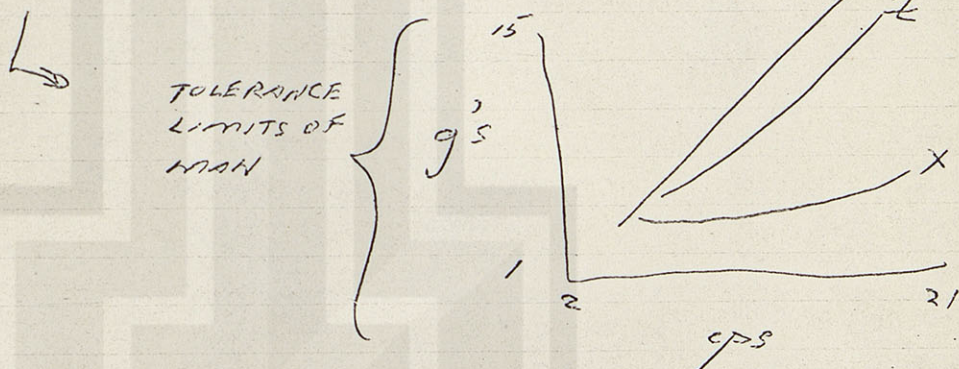
EXPOSING ANIMAL, MAN TO SAME ^{DYNAMIC} ENVIRONMENT DOES NOT
RESULT IN SAME INJURY MECHANISM. TO PRODUCE SAME
INJURY MECHANISM, DIFFERENT DYNAMIC ENVIRONMENTS MUST BE USED.

100g's 10g's 5g's 1g
HAND TOOLS: CHIPPING HAMMER, RIVETING HAMMER, ROTARY HAND TOOL, POLISHING
TOOL
GIVE "10g's" at 1000 cps -
1 to 100 1,000 to 10,000

THIS POSITION MINIMIZES
GRADIENT OF BLOOD PRESSURE
ACROSS BODY UNDER CONSTANT
ACCELERATION (APOLLO POSITION)



HOWEVER, THIS POSITION IS NOT GOOD FOR RESISTANCE BY
MAN TO VIBRATION.



WORKING PAPERS

PHYSIOLOGICAL RESPONSE

TISSUE DAMAGE

SEEKING
NOTES

PAIN 1. to 100
HEATING 1. to —
REFLEX DISORDERS 1. to 500
CARDIOVASCULAR 1. to 200
RESPIRATORY " "
ENDOCRINIC " "
VESTIBULAR whole body
VIBRO-TACTILE SENSATIONS whole body

MEASURED
PERFORMANCE (ERRORS) IS A STRONG FUNCTION OF
VIBRATION FREQUENCY - WORST PERFORMANCE @ 5-16 cps.

AIRBORNE NOISE: HUMAN REACTIONS

OBSERVED PHYSIOLOGICAL RESPONSES

TISSUE DAMAGE
TYMPANIC MEMBRANE DAMAGE
AUDITORY PAIN
RESPIRATORY SYSTEM RESPONSE
VIBROTACTILE
VESTIBULAR RESPONSE
AUDITORY RESPONSE
STARTLE RESPONSE
AUTONOMIC N.S. RESPONSE
ENDOCRINE SYSTEM
EFFECT ON SLEEP

EFFECTS ON PERFORMANCE/ EFFICIENCY

SPEECH COMMUNICATIONS
SENSORIMOTOR TASKS
INTELLECTUAL
FATIGUE

Above 130 db. noise, subjects ability to walk
a rail is markedly degraded - vestibular response.

Effect is worsened if only one ear is protected.

AF Standard Sov	dB	MINUTES
max noise exposure (10 YEARS)	90	140
OLD SKILLED	95	50
300 to 9600 cps	100	25
	105	15
	110	10
	115	7
	120	6

a weighted evaluation of noise annoyance.

WORKING PAPERS

PERCEIVED NOISE LEVEL = SUBJECTIVELY JUDGED ANNOYANCE LEVEL.

By used by FDA.

$$PN(dB) = \text{Weighting Factor} \times \text{true Noise (dB)}.$$

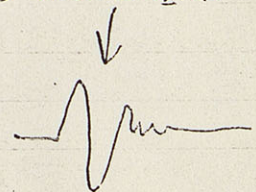
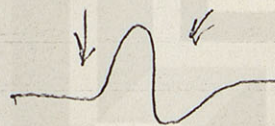
P	1
N	1
E	1
N	1
C	1
I	1
S	1
E	1
V	1
E	1
E	1
G	1

CARDIOVASCULAR Response to noise!

Noise will restrict peripheral circulation: Noise activates autonomic nervous system to this response at levels as low as 75db. This happens even if subject is asleep.

IMPULSE NOISE:

GUNFIRE, BURSTS, DROP HAMMERS



Criticism for
Tolerance.

Problem: By the time practical need for knowledge arises, there is no longer time for research to be carried out, regardless of funding level.
PDIB

WORKING PAPERS

BLAST INJURY: MECHANISM IS RUPTURE OF LUNG RESULTING FROM
INDUCED VIBRATION.

Back at Base

WORKING PAPERS

BILLY WALCH: PHYSIOLOGIC ASPECTS OF ATMOSPHERE SELECTION

FACTORS: P_T , PO_2 , T , PH_2O , TOXICOLOGICAL LIMITS, SOLIDS, INERT GASES.

SOME ATMOSPHERES CONSIDERED:

COMPOSITION	P_{TOTAL}	
AMBIENT AIR:	760. mmHg	mmHg x .50 = psia
" "	522. "	
Lungs PO_2 pressure $\rightarrow$ PURE O_2	190. "	
O_2 /INERT	258 " (71% O_2 / 29% INERT)	

FUNCTIONS OF A HABITABLE ATMOSPHERE:

PHYSIOLOGY

SUSTAIN LIFE

PRODUCE NO IRREVERSIBLE EFFECTS

NOT DEGRADE CREW PERFORMANCE

MISSION - Compatible with EVA, mission length, reliability

ENGINEERING - MINIMUM WEIGHT
" VOLUME
MAXIMUM SAFETY
" RELIABILITY

✓ NORMAL SEALEVEL ALVEOLAR PO_2

SAFE RANGE FOR PURE O_2 ATMOSPHERE UPTO 30 DAY DURATION

$PO_2 = 100$ mmHg

$PO_2 = 170$ mmHg ALVEOLAR OXYGEN TENSION

5 psia PURE O_2 TOTAL PRESSURE.

TWO-GAS CONTROL COMPLICATES ATMOSPHERE CONTROL SYSTEM.

WORKING PAPERS

LAUNCHES WITH
APOLLO 7 60% O₂, 40% N₂ AT ONE ATMOSPHERE PRESSURE.

HYPEROXIC EFFECTS:

CNS : CONVULSIONS } @ 2 to 3 Atmospheres
EEG DEATH
NRS
TUT
RUE
ASM

SUPPRESSION OF RED CELL FORMATION
PEROXIDATION OF MEMBRANE LIPIDS

PULMONARY ATELECTASIS: THOUGHT TO BE A PROBLEM WITH
PURE O₂ ATMOSPHERE ABOUT 1960-1961. IN FACT, IT HAS
NOT BEEN A PROBLEM IN TRAINED SPACECRAFT, ALTHOUGH
IT HAS BEEN REPORTED IN HIGH PERFORMANCE AIRCRAFT.

GROUND BASED STUDIES HAVE NOT SHOWN LOWER ^{RED} CELL PRODUCTION
WITH 70% THAN HIGHER PO₂. QUESTION: DOES SMALL AMOUNT
OF N₂ INHIBIT REDUCTION IN RED CELL MASSES CAUSED BY HIGH O₂?

Hypothesis
based on { APOLLO 7 } 5% N₂ AT TERMINATION OF FLIGHT
APOLLO 8 ← 1 CREWMAN SHOWED DECREMENT
VED CELL MASS.
APOLLO 10 ← 2053 CREWMEN SHOWED DECREMENT
IN VED CELL MASS
and Gemini data.

Or is it an obscure "inert" gas factor.

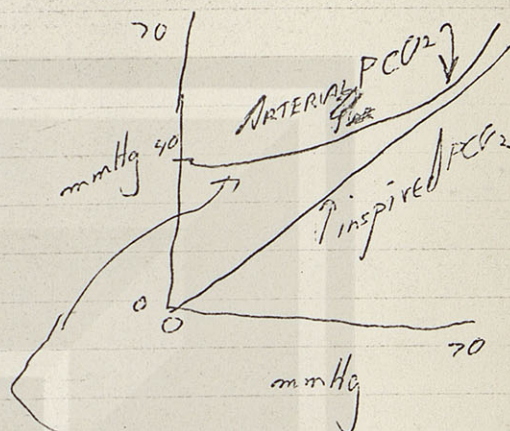
Of great interest since this would be first known biological
interaction of N₂ with organism.

WORKING PAPERS

ARTERIAL $PCO_2 = 40$ mmHg } NORMAL IN MAN.
ARTERIAL pH = 7.40

MECHANISMS FOR BUFFERING OF EXCESS ACID LOAD:

INSTANTANEOUS EXTRACELLULAR
10-30 MIN RESPIRATORY
2-4 HOURS INTRACELLULAR
HOURS TO DAYS RENAL



THIS ACCOUNTS FOR NONLINEAR EFFECT ON ARTERIAL PCO_2

STUDIES OF CHRONIC CO_2 TOLERANCE IN MAN:

PCO_2	DURATION	NO. OF TEST	
15 mmHg	30 days	2 subjects	RUSSIA
11-12 "	42 "	21 "	US NAVY
21 "	30	4	USAF
:			

PCO_2	
0 to 8 mmHg	NO NOTICABLE EFFECT
8 to 15 "	Physical work BARELY NOTICABLE - NO EFFECT ON PER. PERFORMANCE, objective or subjective. Arterial pH measurably lower, but not eff.
15 to 21 mmHg	NOTICABLE EFFECT. HEADACHE. MAXIMUM EFFORT OF PHYSICAL EXERCISE NOTICABLY MORE DIFFICULT.
21 to 30 mmHg	VERY NOTICABLE. HEADACHE. $\frac{2}{3}$ MAX EXERCISE NOTICABLY DIFFICULT.

would be 4% at sea level

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ENERGY COST NOT AFFECTED BY UP TO 30. mmHg PCO_2 IN INSPIRED AIR.

MORE WORK IS NEEDED ON MENTAL PERFORMANCE EFFECTS OF HIGHER THAN NORMAL PCO_2 . WELCH HAS NOT BEEN ABLE TO REPRODUCE MENTAL PERFORMANCE DECREMENTS, AS REPORTED IN SOME LITERATURE.

INSENSIBLE WATER LOSS (CURRENT RESEARCH IN PROGRESS BY WELCH)

LOSS AS VAPOR FROM LUNGS, SKIN.

INSENSIBLE weight (water) loss increases with decrease in total pressure and increases with reduction in ambient PH_2O .
DATA TAKEN ABOVE $28^{\circ}C$ SHOW PROBABLE ONSET OF SENSIBLE WATER LOSS (SWEATING).

WELCH'S OPINION: Helium is not demonstrably preferable to N_2 FOR SPACEFLIGHT. SINCE BIOLOGICAL EFFECT OF INERT GASES IS SIMPLY UNKNOWN, BEST BET IS TO STICK TO N_2 .

JOSEPH P. CORARO
NASA HQ / CART
CHIEF, BIOTECHNOLOGY

ENGINEERING
BIOLOGICAL ASPECTS OF ECS SYSTEMS

WORKING PAPERS

- FUTURE TREND WILL BE TOWARD REGENERATIVE (CLOSED-LOOP) SYSTEMS.
TECHNOLOGY DEVELOPMENT PROJECTIONS FOR NEXT 5 TO 10 YEARS WILL BE DISCUSSED.
- 180 DAYS OR 500 DAYS RESUPPLY INTERVALS OF INTEREST
 - 50 MEN - CREW SIZE OF INTEREST

TEMP MEASUREMENT AND CONTROL				} Integration for closed loop.
CO ₂	"	"	"	
CONTAMINANT	"	"	"	
THERMAL	"	"	"	
PRESSURE	"	"	"	
O ₂ MAKEUP	"	"	"	
WATER MANAGEMENT	"	"	"	
WASTE	"	"	"	
FOOD SUPPLY				

CO₂ SORBENT }
H₂O }
O₂ }
FOOD }

CO₂ - 2.25 #/DAY/MAN
H₂O 13 #/MAN-DAY (5 #/DAY DRINKING; 8 #/DAY WEIGHING)

FOOD 1.5 #/MAN-DAY (DRY)

SOLID WASTES 7 #/MAN-DAY (B) include water content

WHALE BODY CLEANSING.

$$\frac{\text{VOLUME OF CO}_2 \text{ PRODUCED}}{\text{VOLUME OF O}_2 \text{ CONSUMED}} = 0.84 \approx \text{RESPIRATION QUOTIENT}$$

(C)

ENVIRONMENTAL CONTROL FUNCTIONS

CO₂ CONTROL
TRACE GAS CONTROL
PRESSURE SENSING & CONTROL

WORKING PAPERS

20% palladium on Al @ 200°F 211-watts, 9-St.³, 275. #

O₂ SENSORS:

BECKMAN - POLAROGRAPHIC
PERKIN-ELMER - Optical
- Mass Spectrometer

(MISC CONTRACT No.
MISC/LRC MASS SPECTROMETER NAS-9-9799)

↳ will be used to follow rapid changes in partial pressures of breathing; one application already lined up for ground based use.

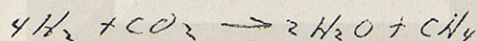
MICROWAVE SPECTROMETERS

Thermal Control:

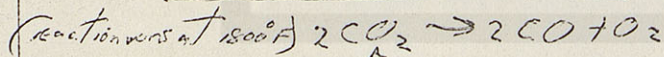
FUSIBLE MATERIALS APPLICATIONS TO DAMP TRANSIENTS.

RECLAMATION OF O₂ FROM CO₂:

SABATIER REACTION:



SOLID ELECTROLYTE REACTION: - Most favored approach.



↓
thromery
(carbon deposition reaction runs at 1000. °F)

} leaky, reliability problems to date.

WORKING PAPERS

WATER RECOVERY SYSTEMS:

DISTILLATION: VAPORIZATION WITH SUBSEQUENT CONDENSATION.

MEDICAL CONSTRAINTS:

STERILE

FREE OF ORGANIC MATERIAL

NO CONTAMINATION DURING SERVICING

EMERGENCY MEANS OF RAPID STERILIZATION, IN EVENT OF INADVERTANT CONTAMINATION.

IN MARCH OR APRIL 1970, MAE WILL DEVELOP ^{THE} A DISTILLATION WATER RECOVERY SYSTEM FUNDED BY OART.

REVERSE OSMOSIS WATER PURIFICATION SYSTEM

USES GLASS MEMBRANE; CAN REJECT MORE

THAN 97% OF ORGANICS

40Å PORE SIZE IS NEEDED. DISSOLUTION

OF GLASS MEMBRANES FROM

HIGH SALT CONCENTRATIONS WILL

INCREASE PORE SIZE AND

SERIOUSLY DEGRADE REVERSE

OSMOSIS PROCESS.

SOLID WASTE MANAGEMENT SYSTEMS:

COLLECT, TREAT, AND STORE WASTE

↳ STERILIZE, AND MAKE INERT.

VACUUM DRYING

VACUUM DECOMPOSITION (HEATING BREAKS DOWN ORGANICS)

WET OXIDATION (i.e. INCINERATION)

IT'S STILL AGAINST INTERNATIONAL AGREEMENT TO DUMP WASTE IN SPACE.

WORKING PAPERS

Food: TREND AWAY FROM FREEZE-DRIED FOOD BECAUSE THEY ARE SUBJECTIVELY UNAPPEALING.

FULLY REGENERATIVE BIO-REGENERATIVE SYSTEMS NOT IN THE CARDS TILL 3600-MAN-DAY MISSION (GIVEN SET GOODBYE).

↓ SOLID STATE OSCILLATORS MAY GIVE 60% EFFICIENCY

MICROWAVE OVENS MAY HAVE GOOD APPLICATION IN SPACE

INFLIGHT MAINTENANCE WILL BE A REQUIREMENT ON LONG-DURATION MISSIONS.

UNMANNED SPACE FLIGHT METABOLIC FACTORS IN LIFE SUPPORT : DR. LARRY DISTLEIN

SPACE FLIGHT STRESSES:

→ FLIGHT PLAN PERFORMANCE REQTS.
SLEEP NEED
ALERTNESS NEED
CHANGING ILLUMINATION
DIMINISHED FOOD INTAKE
DEHYDRATION
VIBRATION
:

MERCURY FLIGHTS:

MEASUREMENTS:

ECG, BLOOD PRESSURE, TEMPERATURE (RESPIRATORY RATE ~~was measured~~ / ~~didn't get~~)
↑
STERNAL LEAD
AXILLARY LEAD
~~ECG~~

GEMINI FLIGHTS:

EEG - CT III
PHONOCARDIOGRAM - 3 flights
(PLUS MEASUREMENTS LISTED FOR MERCURY, ABOVE)

METABOLIC RATES:

BTU/HR	{	350 to 500	- MERCURY FLIGHTS	} Estimated from CO ₂ production measured by LiOH absorption.	
		350 to 400			GEMINI FLIGHTS
		350 to 400			VOSTOK FLIGHTS

Apollo 7, 8

water and electrolytes
 3/4
 WEIGHT LOSS Commander
 WT. loss (#)

WORKING PAPERS

APOLLO 7	6.5
" 8	9.0
" 9	5.5

Heart Rate gives a crude indication of metabolic rate, but emotional influences distort validity.

UNDERWATER SIMULATIONS GIVE BEST SIMULATION OF METABOLIC RATES FOR TASKS TO BE DONE OPERATIONALLY IN ZERO-G.

Apollo 7, 8, 9: @ 120 beats/min 70% decrease in work capability.
 test immediately
 pre & post flight

24 to 36 hours later, upon rehydration and rest, the men were back to normal.

& Armstrong
 Apollo 11 Commander on Lunar Surface

675 to 900 BTU/hr until recovered
 & EVA, when it went
 to ~1400 BTU/hr.

ARMSTRONG had typically higher rates: ~1200 comp'd
 with God For Armstrong.

ASP Med Expts: THERMAL COSTS

WORKING PAPERS

Qualifying men for Mars Mission would take

3. to 4 subjects monitored continuously for
a minimum of 4. to 6. months.

Based on turnover rates within body
of blood cells, and other tissues, there
is nothing really certain about the
adequacy of this min. qualification time

WORKING PAPERS

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FRANK ERVIN: NEUROLOGICAL DATA PROCESSING

- No. of brain cells in newborn human is same as in adult.
- However the number of brain cell interconnections increases dramatically during the first two years of life.
at least

INTRACELLULAR RECORDING:

- IT IS POSSIBLE TO RECORD DATA FROM 1. TO 5. electrodes in the body of an individual nerve cell.

EXTRACELLULAR RECORDING:

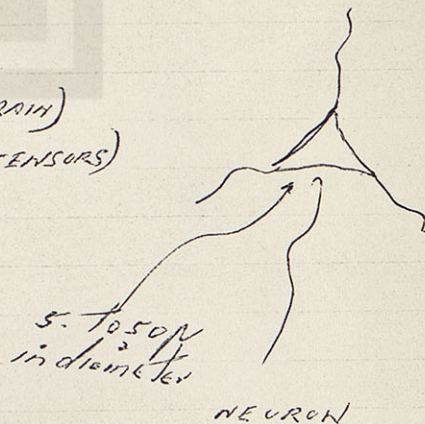
- CAN TELL WHEN NEURON FIRES AND WHEN IT DOESN'T FIRE - CELL FROM HERE LOOKS LIKE A BINARY DIGITAL DEVICE.
- CAN ALSO DETECT INTERACTIONS OF INDIVIDUAL CELL FIRINGS, I.E. SYSTEM OR NETWORK RELATIONS

ELECTROENCEPHALOGRAPHY:

- SMALL FIELDS (SENSOR INSIDE BRAIN)
- LARGE FIELDS (EXTERNAL SCALP SENSORS)

D.C. SHIFTS

THERE ARE ORDERLY SHIFTS IN THE D.C. FIELD WHICH CAN BE RECORDED FROM SCALP OR INSIDE BRAIN - THESE SHIFTS ARE CORRELATED WITH SENSORY STIMULI AND EVEN WITH ANTICIPATED MOTOR RESPONSES.



IMPEDANCE

IMPEDANCE SHIFTS OF GROUPS OF NEURONS - NOT DETECTABLE FROM SCALP SENSORS.

TEMPERATURE

A SMALL THERMISTOR STUCK IN THE BRAIN IS A BETTER SENSOR OF AROUSAL THAN ANY EKG DEVICE.

(Temp. range is tenths and/or hundredths of a degree over range of arousal.)

WORKING PAPERS

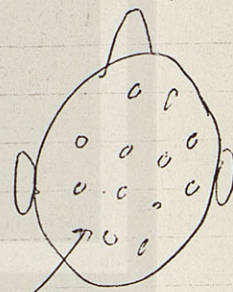
EEG: The most striking feature is that much of an EEG typical trace appears to be sinusoidal merely.

Wwwwwwwwwww

CAROTID SINUS END ORGANS
PLOT OF NEURON FIRINGS
RATE OF FIRING PROPORTIONAL
TO PRESSURE SENSED.

What do you look for in analyzing an EEG?

1. Look for symmetry of the brain which is to be expected.
2. Look for basis or dominant frequency: 8 to 12 Hertz, called the α frequency. "When the brain is apparently doing nothing else, it puts out α waves". 80% of normal adults have α waves dominating EEGs at rest with no



LEADS
LEADS

TOP VIEW OF HEAD
SHOWING TYPICAL
LOCATIONS OF
EEG LEADS

(These are all in 1 cm. from surface of brain).

4 to 7 Hz = θ Frequency
1 to 4 Hz = δ

characteristic of normal sleeping, but pathological in working adult.

3. LOOK FOR UNIQUE EVENTS (NONSINUSOIDAL)

- a) NORMAL - OCCURS SYMMETRICALLY IN AN INDIVIDUAL ABOUT TO GO TO SLEEP WHO GETS A SENSORY INPUT.
- b) ABNORMAL - CHARACTERISTICALLY LOCALIZED; ~~THESE ARE~~

Unique events appear to be indicative of a new instantaneous electrical reorganization of the cortex. This would momentarily effect perception and performance.

WORKING PAPERS

SUBTLE CHANGES IN SCALP EEG TRACES MAY ACTUALLY BE INDICATIVE OF DROSTIC CHANGES IN DEPTH ACTIVITY WITHIN BRAIN (DEMONSTRATED BY SIMULTANEOUS BRAIN PROBE AND SCALP LEAD RECORDINGS.)

"USING SCALP LEADS TO LEARN ABOUT THE WAY THE BRAIN WORKS IS LIKE PUTTING ELECTRODES ON A COMPUTER CABINET TO LEARN HOW A COMPUTER WORKS."

WHAT CAN AN EEG TELL YOU?

1. STATE

AWAKE

DROWSY

ASLEEP

CONVULSING

SEVERELY ANOXIC

behavior over a short time span

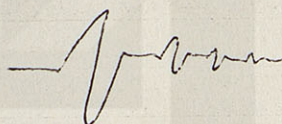
(SUBCORTICAL DISTURBANCE / MICROBEHAVIOR CANNOT BE ~~AND~~ DETECTED AT ~~THE~~ PRESENT.)

2. MICROBEHAVIOR

(EEG IS NOT ~~THE~~ THE BEST PREDICTOR OF BEHAVIOR; THE BEST PREDICTOR OF BEHAVIOR IS PAST BEHAVIOR on a micro scale.)

EVOKED POTENTIALS:

ELECTRICAL
RESPONSE TO
SUDDEN SENSORY INPUT



↑ DECREASING ~~RESPONSE~~ AMPLITUDE (ORDERLY)

CHARACTERISTICALLY STARTS OUT DISTRIBUTED OVER ~~BRAIN~~ CORTIX, THEN LOCALIZES.

EXPOSING SUBJECT TO A SQUARE (■) OR DIAMOND (◆) WILL EVOLVE DIFFERENT POTENTIAL-TIME TRACES.

WORKING PAPERS

EVOKED POTENTIALS ARE PERHAPS USEFUL IN RESEARCH INTO MICROBEHAVIOR.

FELDMAN (M.E. CO WORKER OF DR. ERVIN):

BRAIN HAS 10^{10} ACTIVE CELLS; EACH CELL HAS 100. to 1000 CONNECTIONS WITH OTHER CELLS. ORGANIZATION (INTER-CONNECTING) OF BRAIN CHANGES FROM MOMENT TO MOMENT.

PROBLEM IS THAT ELECTRODE ^{DEPTH} PROBE OF INDIVIDUAL CELLS IS THAT ONLY 3 OR 4 OUT OF 10^{10} CAN BE MONITORED. EEG, THOUGH IT LOSTS FINE-SCALE DETAIL, DOES GIVE OVERALL INDICATION OF INTEGRATED BRAIN RESPONSE - PATTERNS HAVE BEEN CORRELATED WITH BEHAVIOR STATES AS LISTED ABOVE BY ERVIN.

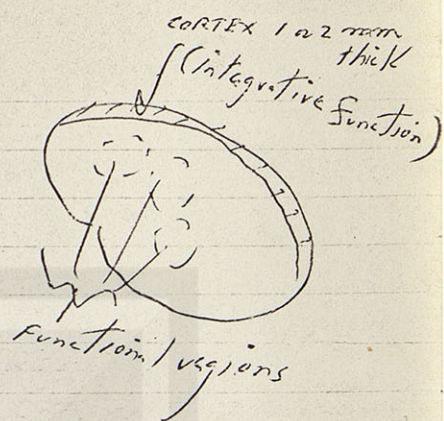
IN DEPTH PROBE TO HIPPOCAMPUS PART OF BRAIN SHOWS THAT EVOKED RESPONSES MAY CAUSE SIGNAL THAT IS AMPLITUDE MODULATED (CAT MAKING A DECISION).

CLASSICAL ASSUMPTIONS OF EEG: SIGNAL IS UNMODULATED ANALOG; TO REDUCE NOISE, AVERAGE SIGNALS AND LOOK AT RESULTS. This has led to positive identification of 5 or 6 half a dozen patterns in the last 80 years. SIGNAL MAY BE MODULATED; THE INFORMATION MAY NOT BE IN THE EEG HAVE BUT IN THE MODULATION OF THAT WAVE.

RESEARCH NEED IS FOR BETTER DEPTH-PROBED DATABASE IN CORTEX AND EVEN DEEPER IN BRAIN.

PRACTICAL APPLICATION OF EEG MONITORING TODAY IS POSSIBLE IN THE SENSE OF USING SCALP SENSORS AND LOOKING ONLY FOR PARTICULAR UNIQUE EVENTS WHICH ARE KNOWN TO BE CORRELATED WITH PATHOLOGICAL BEHAVIOR.

WORKING PAPERS



PROF. SCHWARTZ: ADVANCED CONCEPTS IN BIOINSTRUMENTATION

Applications of dimensional analysis: - consistency of units (lbs., watts, etc.)

ΔH TRANSFORM

$$\Delta H = \sqrt{a(\Delta X^2 + \Delta Y^2 + \Delta Z^2) + \Delta T^2}$$

Biological time (subjective sense) is variable [non-coincident] with clock time.

SUBJECTIVE sense of time may be correlated with body temp., since temp. influences rate of biochemical reactions.

Taking $\Delta H = \sqrt{\dots}$ as above, a summation, what happens if we say ΔH is assumed constant?

PRINCIPLE: USE TRANSFORMS OF RAW DATA THAT PRESERVE THE FEATURES YOU WANT TO PRESERVE AND THROW AWAY WHAT YOU DON'T WANT.

ARCTAN TRANSFORM "MAGNIFIES" LOW VALUES.

$$g(x) = f(x) + \alpha f'(x) + \beta \int_0^x f(x) dx$$

Computer Uses:

On-line transduction and Formatting

TRANSPONSIVE MODE OPERATION

PARTIAL DATA REDUCTION

DISPLAY GENERATION

DISPLAY BUFFERING

"HOW GOES IT" ANALYSIS

EXPT. PLANNING IN DETAIL; SUPERVISION OF EXPT.

"Some lectures compress the same lecture under any given title."

WORKING PAPERS

"FEED FORWARD" PRINCIPLE. IF YOU KNOW WHAT TO EXPECT FROM A SYSTEM, YOU CAN DESIGN DETECTOR SUCH THAT ALARM IS GIVEN (?).

Highest ECG voltage recorded: 2 millivolts

psych. prof. @ Fordham
(KROBIS)

DR. JOSEPH KUBIS: LIVING CONDITIONS AND STANDARDS

Will discuss PSYCHOLOGICAL ENVIRONMENT; RELATIONS AMONG CREW MEMBERS.

GROUP DYNAMICS

A GROUP IS A COLLECTION OF INTERDEPENDENT MEMBERS

A GROUP USUALLY HAS A TASK TO ACHIEVE

GROUP MAINTENANCE DYNAMICS (SOCIAL-EMOTIONAL SATISFACTIONS)

RULES, NORMS DEVELOP AS GROUP INTERACTS

DIFFERENTIATION OF ROLES OCCURS (RIVALRY, COMPETITION RESULT IN LEADERS, OTHER ROLES; GROUP ROLES THEN TEND TO STABILIZE)

INTEGRITY OR COHESIVENESS OF GROUP IS INDICATED BY

→ DESIRE OF MEMBERS TO REMAIN IN GROUP AND COMMITTED TO GOALS OF GROUP.

ISOLATION

CONFINEMENT: EFFECT DEPENDS ON POPULATION DENSITY =

$$\frac{\text{VOL. OF AVAIL. SPACE}}{\text{NO. OF INDIVIDUALS IN SPACE}}$$

TOO-CROWDED CONDITIONS CAUSE PEOPLE TO INTERFERE WITH EACH OTHER IN CARRYING OUT THEIR FUNCTIONS.

ASSUME UP TO 10 MEN IN CREW WITH ONE YEAR DURATION:

Problem in this context
deliberately
distortion.

THE INDIVIDUAL IN THE GROUP:

Comment: Even now medical loss of eyesight, crews assigned to three tend to lose psychological investigation - legend in the field to this day.

NUCLEAR SUBMARINES

TRITON CIRCUMNAVIGATION - EXTENSIVE PSYCHOLOGICAL STUDIES CARRIED OUT. RESULTS

REACTIONS FELT BY SUBMARINERS: DEPRESSION & ANXIETY

ROAR(?)

ANTARCTIC:

ANXIETY (CURE: KEEP YOURSELF BUSY)

DEPRESSION OCCURRED LATER ON

MORE EMOTIONAL EXPRESSION TOWARD END OF TOUR-OF-DUTY.

BEARING ON ENFORCED EATING OF
MEALS TOGETHER.

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WORKING PAPERS

SMITH, REPORTED ARCTIC OVERKIE TRIP:

NEED FOR CHANGE WAS STRONG: WISH FOR EQUIPMENT TO FAIL JUST
FOR EXCITEMENT WAS REPORTED.

SUBMARINERS: 7% OF SUBMARINERS ARE RELEASED FROM DUTY
BECAUSE THEY CAN'T STAND CROWDED CONDITIONS.

30 DAYS, 4 MEN CONFINEMENT STUDY:

(4 men carefully selected from 20 men - given 8 weeks of
preconfinement training.)
60 day 4 men confinement study,
very little difficulty, apparently due to careful
selection and training.

30 days, 5 men confinement study - even not carefully selected,
no extensive training.

Things started out fine, but problems arose overnight.

[Competitive activities were eliminated, because they
introduced too much hostility - results of a
recent Soviet long duration study.
one year.]

Questions Questions for space shuttle:

Possibility of protracted sleep difficulties.

Will work/rest cycles become dominating, resulting in subversion
by crew to seek variety?

Planned innovation may alleviate danger of crew introducing
variety for its own sake.

rotate tasks, leadership.

Group processes: hostility, irritability - danger of this occurring.

Continuing need for response to social demands may cause irritability, hostility.

↓ privacy: psychological sanctuary from continuing social stimuli.

DIFFERENTIATION OF TASK, ROLE, OR STATUS:

IF EVERY MAN IS ESSENTIAL, ROLE COMPETITION SHOULD NOT BE SEVERE.
STATUS LEVELING OCCURS AFTER PROLONGED CONTACT.

STRESS SYNDROME MODEL - WITH STRESS OR EXTERNAL THREAT, GROUP MEMBERS PERCEIVE THE GROUP AS A REFUGE, GROUP BECOMES COHESIVE, BUT PERFORMANCE DEGRADES.

HOMEOSTATIC TENDENCY IN GROUPS: WHEN A DESIGNATED LEADER DOES NOT PERFORM, OTHER MEMBERS STEP IN AND TAKE OVER PORTIONS OF THOSE FUNCTIONS.

SEDLAR II STUDIES: SOCIOMETRIC CHOICES SHOWED GREATER PREFERENCES

HOW SHOULD A GROUP BE STRUCTURED? HOW TO GET A COMPATIBLE GROUP?

GOAL SHOULD BE AN EFFECTIVE CREW: EFFECTIVE individuals do not necessarily form an effective CREW.

TWO DOMINANT INDIVIDUALS IN A GROUP WILL DISAGREE, RESULTING IN LOW GROUP PERFORMANCE.

WORKING PAPERS

KUBS:

SEALAB II AQUANAUTS WERE HIGHLY COMPETENT. THEY ADMITTED TO FALSIFYING ANSWERS TO PSYCHOLOGICAL QUESTIONNAIRES BECAUSE THEY THOUGHT THEM NONSENSE. DIFFERENT TESTING METHODS ARE NEEDED.

PERSONAL SPACE TERRITORIALITY (IN ANIMALS)

LEMNINGES BECOME VERY NERVOUS (ANGER, FIGHTING) DURING THEIR PERIOD OF CROWDING.

Hypothesis: reducing eye contact makes greater physical proximity possible.

SUMMARY: ISOLATION, CONF

RECOMMENDATIONS

1. PROVISIONS FOR VARIETY (TASK COMPANIONS, LEADERSHIP FUNCTIONS)
2. ASSURANCE OF PRIVACY
3. CREW COMPOSITION SHOULD BE SELECTED FOR COMPATIBILITY
4. TRAINING IN RELEVANT ASPECTS OF GROUP DYNAMICS.
5. RESEARCH INTO GROUP DYNAMICS.

[KUBS: ALL GROUND ANALOGS OF HUMAN FACTORS IN SPACE FLIGHT COM AT PRESENT DO NO MORE THAN PROVIDE HINTS OF WHAT MIGHT BE PROBLEMS IN SPACE]

See Results of McDonnell-Stick reported at Aerospace Medical Association Meeting this year.
 ↓ primarily systems, toxicology oriented.

RAYMOND LOEWY: SPACECRAFT HABITABILITY

VOLUMETRIC UTILIZATION
FUNCTIONAL AREAS, EQUIPMENT.

Joseph KUBIS definition:

"AN ENVIRONMENT IS
HABITABLE $\rightarrow$ IF MAN CAN FUNCTION AS MAN WITHIN ITS CONFINES."

COMPONENTS OF HABITABILITY $\left\{ \begin{array}{l} \text{PHYSICAL} \\ \text{PSYCHOLOGICAL} \\ \text{SOCIAL} \end{array} \right. + \text{"LEGISLATED CONCEPTS"}$

ASTRONAUTS HAVE REPORTED

THAT WEIGHTLESSNESS HAS THE EFFECT OF MAKING A GIVEN VOLUME
SEEM LARGER.

ROTATING ARTIFICIAL G - a mixed blessing because of coriolis effects
on vestibular system.

FOOD MANAGEMENT & WASTE MANAGEMENT WILL BE DISCUSSED
IN DETAIL FROM HERE ON OUT IN THIS PAPER.

AAP Waste Management Component: Loewy^{re} design
made it possible for use of only one
to their station to reach all equipment
in there.

FOOD MANAGEMENT component in AAP: Loewy
suggested it might double as a word room
for leisure time recreation and sociability.

To fight vestibular effect in rotating
or tilting g, have controls stacked up
vertically to minimize side-to-side
motion of head.

WORKING PAPERS

JOSEPH MacINNIS: INTRODUCTION TO UNDERSEA MEDICINE

RECENT OCEAN SYSTEMS, INC. WORK - BUFFALO, N.Y.
8 MIN TO 800 FT
(HOLD FOR 30 MIN.)

10 MIN AT 1000 FT

LABORATORY EXPOSURE TO PRESSURES AT GREAT DEPTH.

NO. OF UNDERSEA PHYSICIANS WHO DIVE AND DO LAB. WORK IS LESS THAN 5.
AT PRESENT

GAS, PRESSURE, TEMP EFFECTS GOVERN MAN'S TIME & DEPTH IN SEA.

↑↑

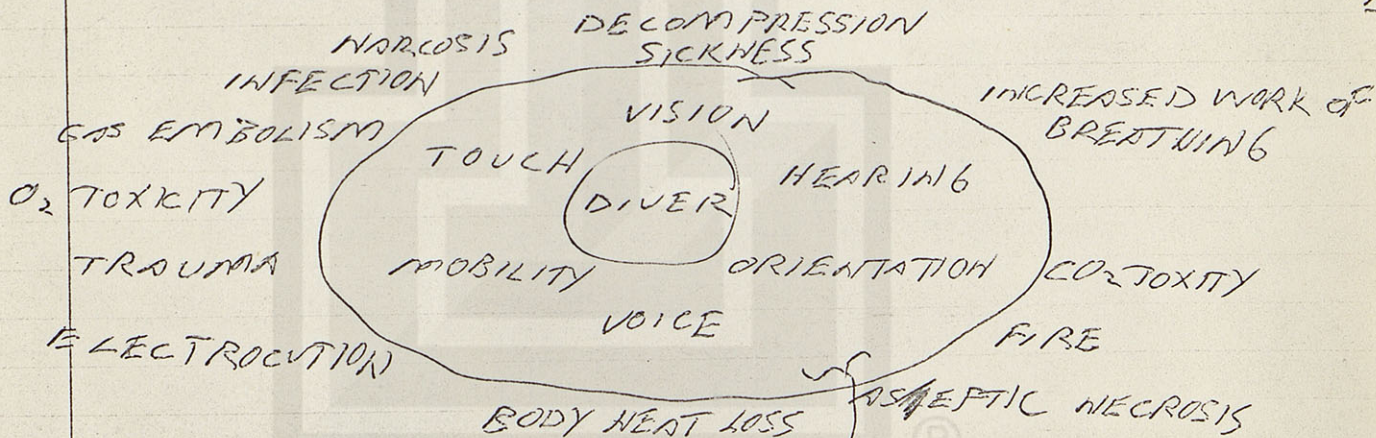
MINIMAL MEDICAL PRESSURE PROBLEMS OCCUR
IN DEEP-DIVING VEHICLES THAT MAINTAIN
1 BAR INTERNAL PRESSURE.

EXAMPLE: "DEEP DIVER"

4 MEN

1200' DEPTH

UNDERSEA MEDICINE IS REALLY CONCERNED WITH
THE FREE DIVER EXPOSED TO AMBIENT PRESSURE.



VISION:

30% MAGNIFICATION
UNDER WATER; 60% DECREASE
IN VISUAL ACUITY

WORKING PAPERS

HEARING: CAN'T JUDGE MAGNITUDE, DIRECTIONS,
OF UNDER WATER SOUNDS

VOICE: HELIUM VOICE PROBLEM.

TOUCH: TACTILE SENSATION IS DIMINISHED - LIKE
WEARING A PAIR OF THICK COTTON GLOVES.

DECOMPRESSION SICKNESS: ^{BELOW 200'} 2. to 3% OF DIVES RESULT
IN DECOMPRESSION SICKNESS. [GAS BUBBLES IN TISSUE.
(MOST SERIOUS PROBLEM FACING UNDERWATER MAN TODAY)

THERMAL INSTABILITY: PROLONGED EXPOSURE - NO WAY AT
PRESENT TO OVERCOME EXCESSIVE HEAT LOSS
(2nd MOST SERIOUS MED. PROBLEM TODAY FOR MAN UNDERWATER.)

TRAUMA: SERIOUS PROBLEM - getting in the way of large
moving masses.

O₂ TOXICITY

- a.) ACUTE
- b.) CHRONIC

0.3 BAR TO 1.2 BAR DURING DIVES
2. TO 3. BAR } DURING DECOMPRESSION

GAS EMBOLISM: OCCURS DURING BREATH-HOLDING DURING
ASCENT.

TRANSIENT BREATH-HOLDING SUCH AS IN SNEEZING
AND COUGHING CAN CAUSE GAS EMBOLISM
DURING RAPID ASCENTS.

SKIN EFFECTS UNDERWATER, SKIN TEARS MORE EASILY.

N₂ NARCOSIS

From 200' ~~down~~ DOWN, EACH ADDITIONAL 50' OF DEPTH
CAUSES SENSATION OF A DRY MARTINI ON AN
EMPTY STOMACH.

(HELIUM IS NOT NARCOTIC DOWN TO AT LEAST
1000 FT. - and possibly beyond that; no
experience or data at present.)

INCREASED WORK OF BREATHING: RESULTS FROM HIGHER
DENSITY OF BREATHING GAS AT HIGH PRESSURE.

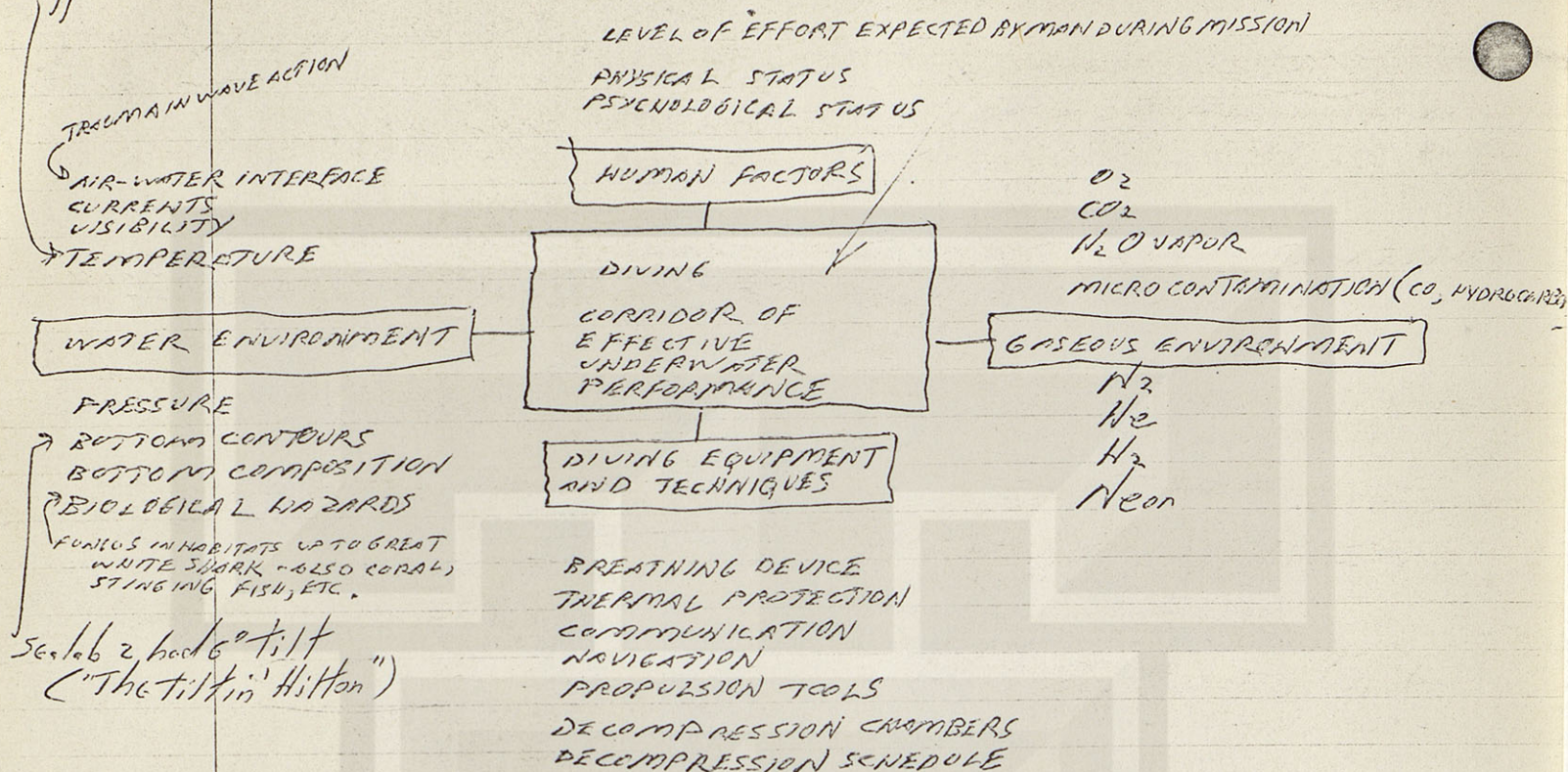
CO₂ TOXICITY: P_{CO₂} maintained below ~~1%~~ 1% equiv. of sea level.

ASEPTIC NECROSIS: Small, local regions of the long bones die -
symptoms may be insidious or ~~is~~ in a joint -
it can be a problem.

~~Not treated~~
(Greater the depth and greater exposure, the
greater the risk.)
This occurs on land too - it isn't yet known
even if diving triggers this; incidence is
however higher in diving than on land.

supplementing heating probably needed

this corridor "narrows" with increasing depth



Sealab 2 had 6° tilt ("The tiltin' Hilton")

EFFECTS OF CURRENT:

UP TO 1/2 KNOTS - CAN PERFORM UNIMPEDED
 IN CURRENTS OF 1 " - CAN PERFORM WITH DIFFICULTY
 > 1 1/2 " - HE HAS ALL HE CAN DO TO "DRAG ON"

OCEAN TEMPS.:

28° to 86° F } range of ocean temperatures (mostly in lower end of range)

O₂/He atmospheres need to be at 86° to 88° F for thermal equilibrium in man because of higher thermal conductivity of Helium.

WORKING PAPERS

OCEAN ENGINEERING AXIOM: INCREASE MAN'S ABILITY TO WORK UNDERWATER WHILE EXPOSING HIM AS LITTLE AS POSSIBLE TO THE HOSTILE ENVIRONMENT.

OCEAN SYSTEMS, INC. SUBMERGENCE SYSTEMS:

ADS-4 - CARRIES MAN DOWN TO WHERE TASK IS, AT AMBIENT CONDITIONS.

15' mean wave height

35' peak " "

36°F AVERAGE WATER TEMP.

max depth: 3000.5 ft.

THERE'S
CHAMBER
IS RAPIDLY
PRESSURIZED
SO MAN CAN GO
OUTSIDE AND
WORK FOR 20-30
MINUTES.
LONGER OUTSIDE
EXPOSURES COST A
LOT IN DECOMPRESSION
TIME AND ALSO
GIVES RISE TO EXCESS
THERMAL LOSS.

"THE QUEST FOR OIL UNDERSEA IS WHAT HAS STIMULATED COMMERCIAL DOLLARS TO FUND DEEP DIVING RESEARCH."

FIRST DIVING BELL TO CARRY OUT SOPHISTICATED DIVING (SATURATION DIVING, O_2 /He atmosphere) WAS BUILT IN 1962.

A SATURATED DIVER IS ONE WHO HAS SPENT MORE THAN 24 HOURS AT A GIVEN DEPTH.

(DECOMPRESSION-TIME RQA. DOES NOT INCREASE FOR EXPOSURES BEYOND 24 HOURS.)

WORKING PAPERS

WORKING PAPERS

SUMMARY OF A 4 MAN (DRY CHAMBER) EXPOSURE TO 650. FT.

EXPOSURE FACTORS :

PRESSURE 650. FSW
(20.7 ATA)

O₂ 0.35 ATA

CO₂ <1% SLE

INERT GAS (He) 20.3 ATA

T 85° to 88°F

R. HUMIDITY 75 to 90%

TRACE CONTAMINANTS : INSIGNIFICANT

NO DETRIMENTAL EFFECT ON MAN, EITHER ACUTE
OR LATENT.

O₂/He work began in 1937.

800 ft dive: Keller 1960.

Since 1960, saturation diving has made many deep dives possible.

Cornex (1968) 1190' - brief period, but deepest
France manned dive
50 Sat.

Two deepest man-rated chambers in the world are in
Marseilles, France : Cornex (4000 meters)
Sermis (5,000 ")
↑
Coulson

KARL SCHAEFFER: PHYSIOLOGICAL ASPECTS OF UNDERSEA ACTIVITY

TEXT: "THE PHYSIOLOGY AND MEDICINE OF DIVING & COMPRESSED AIR WORK,"
 GOOD BOOKS: PHYSIOLOGY ... BY BENNETT & ELLIOTT,
UNDERWATER PHYSIOLOGY, LONDON (BAILLIERE TINDALL & COSSGILL 1969)

PRESSURE EFFECTS:

- a) GAS CONTAINING SPACES IN THORAX ARE COMPRESSED. AT 100. TO 150. FT. DEPTH THE THORAX WOULD NORMALLY COLLAPSE. (BREATH-HOLD DIVERS COME TO 240. FT. ^{BECAUSE OF 60. FT. ST. ST. TO THORAX})
- b) DIFFERENCES BETWEEN HYDROSTATIC PRESSURE AND DRY-CHAMBER PRESSURE.

AT 66 FT. DEPTH, VOLUME OF LUNG IS ONLY $\frac{1}{30}$ NORMAL WITHOUT AQUELUNG.

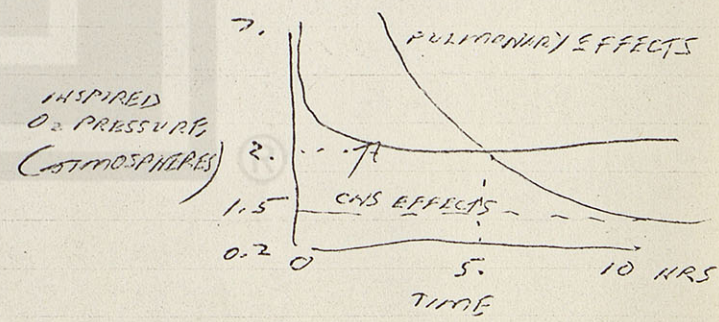
c) N_2 EFFECTS

AT 200 TO 300 FT. DEPTHS, N_2 NARCOSIS RESULTS; A SLOWING OF THOUGHT, EFFECTS BEING SIMILAR TO THAT OF ALCOHOL INTOXICATION.

d) O_2 TOXICITY

YOU CAN ~~INCREASE~~ CHANGE O_2 THREE TIMES ABOVE OR THREE TIMES BELOW NORMAL LEVEL - OLD RULE.

PULMONARY SYMPTOMS OF CHRONIC EXPOSURE
 sublethal CENTRAL NERVOUS SYSTEM EFFECTS (CONVULSIONS, DISTURBS FAINTING): HIGH PRESSURE ACUTE EFFECTS.



WORKING PAPERS

Low O_2 Pressure
 → CLEAR MIND
 Balloon experim.
 LACK OF ABILITY
 TO CONTROL LIMBS,
 LOW MOTION

HIGH O_2 Pressure
 CONFUSED MIND
 CONVULSIONS - HYPERACTIVE,
 UNCONTROLLED MOTION.

e) CO_2 effects: HIGH Pressure causes euphoria
 Heightened awareness of color
 Restlessness, body movement
 Mental disorientation
 LARGE INCREASE IN VENTILATION
 People have great variability
 in their response to CO_2 :
 Slow breathers have a
 high tolerance to CO_2
 Fast breathers have a
 low tolerance to CO_2

Experienced divers become CO_2 tolerant and
 stress resistant (adrenaline injections have only
 modest effect on heart rate.)

Shallow water blackout results from too high CO_2 .
 Deep " " " " " "

INCREASED WORK OF BREATHING?

Experienced divers let CO_2 levels rise internally,
 rather than increasing ventilation rate as "new" men do.

BUBBLE FORMATION:

GASES DISSOLVE IN BLOOD IN AMOUNTS DEPENDENT ON PRESSURE
 (HENRY'S LAW).

THERE ARE FAST AND SLOW TISSUES IN THEIR RESPONSE
 TO DISSOLVED GAS, DEPENDING ON RATE OF PERFUSION
 OF BLOOD TO THESE TISSUES (HIGH PERFUSION MEANS
 FAST TISSUE UPTAKE OF DISSOLVED GAS IN BLOOD.)

RECENTLY EFFECTS OF TISSUE DIFFUSION HAVE ALSO BEEN
 FOUND.

WORKING PAPERS

FAST AND SLOW TISSUES MUST BE ACCOUNTED FOR IN
CONSTRUCTING DECOMPRESSION TABLES.

WHEN BUBBLES OF GAS OCCUR IN SPINAL CORD OR BRAIN,
THEY PRODUCE PARALYSIS; IF IN LUNGS, THEY PRODUCE
CHOKES.

HALDANE^(?) (1937) introduced stage decompression:

Any one can go from pressure x to $\frac{1}{2}x$ instantly
without ill effect. Then he ^{must} stay ~~at~~ there
a while before next stage of decompression.

~~At~~ Near end of decompression, elimination of
the from body can be accelerated by breathing
pure O_2 .

BREATH HOLD DIVING:

POLYNESIAN, GREEK SPONGE DIVERS.

U.S. NAVY EMERGENCY ESCAPE TRAINING.

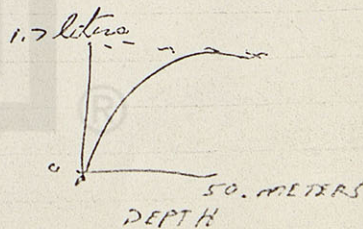
IN BREATH HOLDING DIVING, CO_2 IS NOT A PROBLEM; BUT
LOW O_2 PRESSURE ON ASCENT NEAR SURFACE
IS THE BIG PROBLEM (HYPOXIA).

OF BREATH HOLD
DIVING

CO_2 controls urge to breathe - hyperventilation increases risk of
hypoxic blackout reaction on ascent towards surface.

TOTAL O_2 REQD. PER DIVE

↓
reaches an asymptotic max.
What is mechanism.



WORKING PAPERS

In breathholding diving, as lung gas volume decreases,
amount of blood in the thorax increases which compensates
for volume loss due to gas compression.
approx. 1 liter

AIR EMBOLISM:

HEATING

INFLUENCE OF CIRCADIAN CYCLES:

RESPONSE OF LACTIC

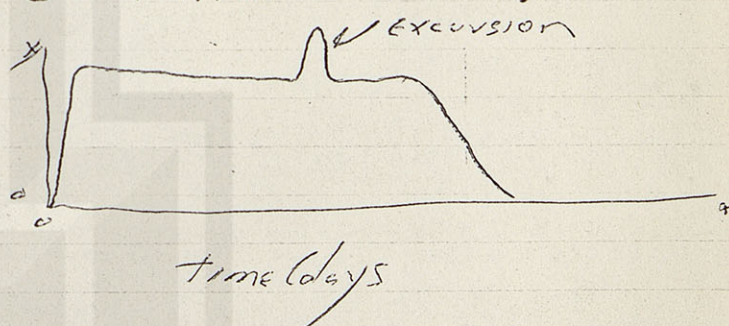
DRUG TOLERANCES ARE DIFFERENT UNDER HIGH PRESSURE AS
COMPARED WITH SEA LEVEL.

R₂ HYDROGEN-OXYGEN ATMOSPHERES CAN BE USED AT DEPTH
WHERE H_2/O_2 IS NOT AN EXPLOSIVE MIXTURE.

Excursion Diving FROM SATURATION:

Example:

DEPTH



RATE OF COMPRESSION IS AN IMPORTANT EFFECT AT
DEPTHS GREATER THAN ~400 FEET.



W. H. H.

No. DIVES 300' on air

BENDS
II I

USN TABLE 58	6	1	2
WORKMANS M VALUES	3		3
CONTINUOUS			
CONSIDER	10		2

We still lack the fundamental knowledge to describe the bends phenomenon in order to predict it.

WORKING PAPERS

THIS STEP IS
NOT NECESSARY

PM D. Sc. going to OST.

EDWARD J. BURGER: DEMONSTRATION OF LIQUID BREATHING

8. MINUTES
DURATION
ON LIQUID
BREATHING

- 12:10 P.M. 1. ANAESTHETIZE MOUSE ^{not water-on-the liquid: FX75}
- 12:14 P.M. 2. PLACE MOUSE IN ~~H₂~~ WHICH HAS BEEN SATURATED WITH
O₂ BY BUBBLING O₂ THROUGH THE WATER,
3. MOUSE MOVES SPASTICALLY - gasps, while water
enters lungs. - about 30 seconds duration.
- 12:22 P.M. 3. REMOVE MOUSE FROM FX75. ←
4. HOLD MOUSE UPSIDE DOWN; WATER DRAINS
FROM LUNGS.
- 12:22-30 P.M. 5. WRAP MOUSE IN HEATING BLANKET
- 12:26 P.M. 6. MOUSE REVIVED AND WALKED OUT OF FOLDS OF
BLANKET AT HIS OWN VOLITION; WALKING WAS REALLY
"STAGGERING".

7. Some mice have been repeatedly used; recovery appears
to be complete.

LIQUID BREATHING: REPLACE INERT N₂ BY A LIQUID.

DROWNING IN SEAWATER TAKES LONGER THAN DROWNING IN FRESH WATER

POSSIBLY FUTURE PRACTICAL APPLICATIONS OF LIQUID BREATHING:

space application
high gs to
the strus

1. PROTECTION FROM HIGH ACCELERATIVE FORCES
2. ELIMINATION OF BENDS IN RAPID ASCENT

WORKING PAPERS

LIQUIDS WHICH HAVE BEEN TRIED FOR LIQUID BREATHING:

WATER

SALT WATER

SALINE

BUFFERED SOLUTIONS

FLUORINATED HYDROCARBON

← quite inert

LIMITATIONS TO LIQUID BREATHING:

1. Don't want fluid that is soluble in body fluid to avoid diffusion or concentration of body fluid
2. Temp. One does better by decreasing temp. 18° to 20° below normal
3. Toxicity: Fluid must be non-toxic CO_2
4. OXYGENATION: solubility of O_2 in liquid or diffuses slowly through liquids
 $\therefore$ there is a gradient of O_2 gases within each alveolus.
 diffusion is a limiting factor in liquid breathing.
 can be eased by raising pressure.

Entry of liquid into lungs: strong cough reflex
 No pain sensors in lung; Bels.

24. Hours in FX75: max. survival duration on liquid breathing.

↓
 Jackson & Slings effective

FX75 EVAPORATES QUITE RAPIDLY AND DOESN'T DISSOLVE IN SALINE, ~~or~~ BODY FLUID. AND IS LESS VISCOUS THAN SALINE; ITS INERT.

CAPT. GEORGE BOND: MAN'S ROLE ON THE OCEAN FLOOR(19th century)REMARKS.

- Berd's or decompression sickness was originally known as caisson disease.

Haldane

Developed concept of stage decompression

- NITROGEN NARCOSIS (at ~ 200 ft. depth) (~ 1900)

By 1935 men were diving on Helium and Oxygen.

Thereafter, big problem in deep diving was decompression time.

About 1957 the concept of saturation diving sprang up:

Give man a habitat undersea for depths below 200!

then his decompression time or penalty would be fixed.

much above 200. m.h.g. PO₂ gives oxygen toxicity.

In 1957, about 50% of physiologists thought this was necessary chronically.

SEALAB BEGAN THEREAFTER. Little Sinking, but resulted in SEALAB I habitat, which was put down off Bermuda @ 133' depth with 4 Southerners even for 11 days.

thresher investigating group recommended that SEALAB type activity be stopped.

GEORGE BOND was put in charge of SEALAB II.

450. MAN-DAYS OF EXPOSURE RESULTED.

SEALAB III was to be in clear but cold water off SAN CLEMENTE ISLAND, CALIF. AT A DEPTH OF 600. FT.

WORKING PAPERS

Helium: Thermal conductivity is 6 times that of air at sea level
14 " 1 " " " at 600' depth.
∴ habitat needs to be heated.

INSULATION IS A PROBLEM: FOAM TYPES FILL WITH HELIUM AND LOSE INSULATION PROPERTIES.

"VIRTUALLY NO SHELF EQUIPMENT THAT YOU WOULD WANT TO WORK WITH WILL WORK ^{IN} HELIUM"

VIBRICAL CABLE TO HABITAT: emergency gas line
Viola
48 connectors
Communications line.
was banded, spotted - but Helium under pressure burst it.

Helium will permeate through the glass of a TV tube.

HELIUM VOICE - Best unscrewdrivers still don't do a adequate job.

A diver in the open water breathing Helium cannot today communicate with another diver.

Another problem is that dead space in masks must be kept to 12 cc to minimize CO₂ buildup.

→ STABILITY - Sunday was normally a day of comparative rest.
30 days for Scott CARPENTER, others 15 day tours.

205' depth off La Jolla, CALIF.

WORKING PAPERS

SEALAB III, essentially the SEALAB II habitat

Saturday - lowered habitat to 610 ft. of
water unmonned. (clear water).

Sunday A.M. - multiple leaks in
habitat [10,000 $\text{ft}^3/\text{hr.}$]
Water temp. 52°F
~~seals~~ seals shrunk.

Benny Cannon - dead aquanaut; died from overexposure
to high PCO₂ - Boyle's law wasn't
put in context.

SEASIDE will go down ^{again} sometime around next Mth.

For the Suprem^y

Deep diving physiology: most of the answers are known.
" " " physics: modality of gas transport in tissue
median gas partial pressure in situ in tissue
Bubble formation & resorption
Stagnant bubbles in blood can be
hazardous.

Material gains a deep diving arc primarily on continental shelves.

Helium is probably okay down to 1,800 ft.
By day, ex " " " " " 3,000 ft.

Below that, liquid breathing -

↳ CO₂ rephosphorylation being limiting factor in denaturation.

IN MANUFACTURE OF FX 50 to date,
contamination has not yet been eliminated.

~~Gen~~ Assuming

13,000 ft. depth research sub. and liquid breathing
would make 50% of ocean floor accessible.

1200. watts to keep a man heated underwater.

At present it should be possible to develop a
helium vocabulary - since some sounds come
through better than others.
GINNIS: JAPANESE IS NOT MUCH OF A
PROBLEM IN HELIUM.

~~End~~ ~~3-11-68~~

7 mL O₂ / LITER OF SEAWATER $\rightarrow$ max. concentration
of O₂ in sea water (ev)
occludes ~~soft~~ inorganic
and anoxic.

ARTIFICIAL GILL CONCEPT APPEARS TO BE OUT BECAUSE OF
SEA WATER FOULING BY MARINE LIFE (SMALL).

ELECTRICAL POWER ON THE SEA FLOOR; "WINDMILLS" USING TIDAL
CURRENTS. WATER BEARINGS, CONCRETE (TO AVOID
CORROSION).

SEA FLOOR ADVANTAGE: NO COSMIC RAYS - RADIATION-FREE
ENVIRONMENT.

GORDON
DR. ^{AVIATION} NORWOOD
PETER SIEGEL : MEDICINE AND CERTIFICATION

WORKING PAPERS

66

PRESENT STANDARDS REQUIRE MEDICAL ^{RE-}CERTIFICATION FOR COMMERCIAL PILOTS EVERY SIX MONTHS.

FAA IS A REGULATORY AGENCY - THEY ~~RE~~ PROVIDE MINIMUM MEDICAL STANDARDS.

LEGISLATIVE BASIS OF MEDICAL CERTIFICATION:
FAA ACT 1958

General aviation accident rate is much higher than for the common carriers.

Flying, ~~as~~ like auto-driving, is legally a privilege, not a right.
ADMINISTRATIVE PROCEDURES ACT GOVERNS AND RESTRICTS THE RULE MAKING POWERS OF FEDERAL REGULATORY AGENCIES:

1. PUBLIC HEARINGS REQ'D.
2. MUST BE SUPPORTABLE BY SUBSTANTIVE EVIDENCE.

ABSOLUTE SAFETY IS NOT FAA GOAL BECAUSE EXPENSE WOULD BE INTOLERABLE.

→ MAJOR CONCERN OF FAA IN MEDICAL CERTIFICATION: SUDDEN INCAPACITATION OF PILOT IN FLIGHT.

ARTERIOSCLEROTIC HEART DISEASE

DIABETES

INDISCRIMINATE USE OF DRUGS & ALCOHOL

EPILEPSY

MENTAL DISORDERS

→
MOTOR SKILLS }
JUDGMENT } KEY ELEMENTS IN PILOT PERFORMANCE

STANLEY MOHLER: CIVIL AVIATION ACCIDENT INVESTIGATION AND
RESEARCH

→ CAUSES OF FATAL ACCIDENTS IN GENERAL AVIATION:

1. ALCOHOL 30% OF FATAL ACCIDENTS
2. BUZZ JOBS 30% " " "
(UNWARRANTED LOW
LEVEL MANEUVERS)
3. DELIBERATE PENETRATION 30% OF FATAL ACCIDENTS
OF ADVERSE WEATHER

• FATAL ACCIDENTS IN GENERAL AVIATION:

	1963	1964	1965	1966	1967
NO. OF ↓ TOTAL FATALITIES	900	980	1020	1,123	1200
NO. OF ↓ TOTAL ACCIDENTS	477	510	543	564	605
% OF CORPSES ON WHICH AUTOPSIES WERE PERFORMED	29%	42%	54%	62%	69%

~~The~~ ^{more than} ~~the~~ [^] C.B.S. ~~of~~

% OF AUTOPSIES TAKEN WHICH SHOWED MORE THAN 0.015% OF ALSO HCL IN BLOOD	43%	39%	36%	27%	22%
---	-----	-----	-----	-----	-----

decrease the top public education program most
intensive in 1966

Even one ^{alcoholic} drink is unacceptable in flying - in Sluvern
within 8 hrs. of flying

WORKING PAPERS

LESS THAN 3 DRINKS	0.015 %
3. TO 6. DRINKS	0.5 to 0.99 %
6. TO 9. DRINKS	1. to 1.49 %
MORE ^{THAN} 10 DRINKS	> 1.5 %

26 %
17 %
19 %
38 %

autopsied
9005 individuals with
alcohol in blood at
various levels.

There are now two very specific techniques for detecting ^{ETANOL} alcohol in blood:

1. gas chromatography
2. ETANOL ACETALDEHYDE DEHYDROGENASE.

Buzz Jobs - significantly correlated with wise guy / friend problems.

NOVERSE WEATHER

TODAY IT IS VIRTUALLY IMPOSSIBLE TO INADVERTANTLY GET INTO BAD WEATHER DUE TO EXCELLENT AVIATION METEOROLOGY. "GET-THERE-ITIS" IS PRESUMED TO BE THE CAUSE OF DELIBERATELY GOING THROUGH BAD WEATHER, -D- THE URGE TO GO STRAIGHT WHERE YOU'RE GOING REGARDLESS OF WEATHER ON ROUTE.

GENERAL AVIATION
EFFECT OF AGE ON ACCIDENTS! $\propto$ all accidents, 50% / 100%

CERTIFICATE	AGE (YRS.)			
	16-29	30-41	45-59	60 to 70 and above
STUDENT	60.	94	111	82
PRIVATE	126.	118.	120	113
COMMERCIAL	254.	146.	109	123
ATP	298	118	59	104
COMMERCIAL				

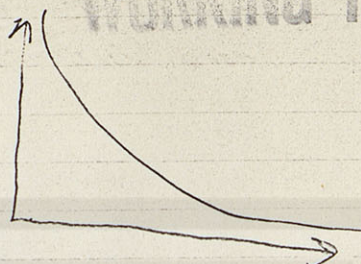
MIN. AGE
18 YRS
PRIVATE
23 YRS.
COMMERCIAL
ATP

TABLE ENTRIES ARE ACCIDENTS PER 10,000 ^{PILOTS} OF THE POPULATION INDICATED -

common carrier pilots flying general aviation planes, included in this table.

WORKING PAPERS

ACCIDENT RATE
PERCENT OF
PILOT POPULATION



FLYING HOURS WITHIN LAST
MONTH OF ACCIDENTS

MECHANICAL FAILURES ARE AN ALMOST NEGLIGIBLE CAUSE OF
GENERAL AVIATION ACCIDENTS.

WAYS TO REDUCE FATALITIES FROM FIRE AND SMOKE.

GELLED FUEL - FAR DISTANT FUTURE

NONFLAMMABLE MATERIALS IN CABINS - NOT AVAILABLE IN QUANTITY.

SELF-CONTAINED AIRSPACE FOR INDIVIDUAL ("PASSENGER
ANTI-SMOKE HOOD")

WORKING PAPERS

65

United Airlines

MEDICAL ASPECTS OF COMMERCIAL AVIATION: GEORGE KIDERA

15 to 20% of pilots with class I licenses are disqualified at hiring by United Airlines - health must be better than FAA minimum standards.

If a pilot misses a flight, he must go through a medical check.

United Airlines "bottle to throttle" rule: 24 hours for pilots; 12 hours for stewardesses.

The pilot has a circadian rhythm. Say de tox, say alcohol. Peak at 5 PM, rain at midnight.

UNITED AIRLINES

ECG Resting
Double Masters stress ECG

TENOMETRY

AUDIOMETRY

GLUCOSE CHALLENGE (sugar dose - checking sugar, blood sugar)

INTERMEDIATE VISION

AP & LATERAL CHEST X-RAY

CBC

SED RATE

URIC ACID (GOUT)

BUN

TOTAL CHOLESTEROL

SEROLOGY

SICKLE CELL TRAIT

TRIGLYCERIDES

common in Negroes and med. terrain people associated with infection of the spleen.

↑ can be reduced by STROBIN - reduction significantly in heart disease reduction?
REDUCED MYOCARDIAL INFARCTION RATE.
↑ elevated TRIGLYCERIDES in blood associated with myocardial infarction.

U.A. PILOT GROUNDINGS 1938 - 1969

WORKING PAPERS

71 CARDIOVASCULAR

22 PSYCHIATRIC

AGE GROUP	NO. OF CORONARY ARTERY DISEASE OCCURENCES
30-39	1.6
40-49	4.25

} per thousand men years in general population 1938 through 1969.

Exercise has shown that a lousy ECG can be shaped up.

PRESSURIZATION

→ 8.7 psia - DC-8 pressurization

DEATHS IN FLIGHT -

1946 - 1967 76 passenger deaths 0.42/million passengers
carried.

OZONE AT SET ALTITUDES (35,000 to 40,000 Feet)

Max. 0.08 ppm in flight.

Ozone doesn't move with weather system.

0.1 ppm 6% OF FLIGHT

WORKING PAPERS

MEASURED IN COCKPITS
RADIOACTIVITY AT SET ALTITUDES:

{	76.8 MILLIROENTGENS / YEAR	}	PACIFIC OPERATION
	86.4 " "		US. DOMESTIC

cockp. dose - measured.

No radiation found at 31,000 - 40,000 ft. ^{during} ord. of Stev Russian
 50. megaton bomb blast.

C-2

C-3 BLIND

A-4 ^{not} shielded.

TURBULENCE:

WORKING PAPERS

Consideration being given to deletion of passenger emergency O_2 . There has never been an explosive or rapid decompression in modern commercial aviation in U.S. but there have been significant surges. PO_2 presented to passengers in over 1000 severe cases, usually half the passengers just look at them.

70% to 80% of commercial failure should be survivable.
unburned hydrocarbons can make you feel euphoric-like alcohol.

INDIVIDUAL TOLERANCE TO CIRCADIAN SHIFTS IN
TIME ZONE TRANSFER VARIES GREATLY.

Jacques Picard: UNDERSEA EXPLORATION

WORKING PAPERS

30 days in "Ben Franklin" drifting with Gulf Stream.

Greenhouse, \$15.00 + other money.

Ben Franklin: GOAL: TO DRIFT FOR A MONTH IN THE GULF STREAM

Why drift? To get continuous observation time, rather than a few hours as with Trieste.

Fish are frightened by moving submarine - periods of observation over few hours life.

By drifting noiseless, min. disturbance of environment is obtained.

GASOLINE BOAT WAS USED
gasoline more compressible
than water.

The TRIESTE has no capability to hover.
it is vertically unstable.

MILITARY SUBMARINE - hull is more compressible than water.

BEN FRANKLIN GOAL was... to be less compressible than water. Thus it is stable, since as it sinks it becomes more buoyant while as it rises it becomes less buoyant due to density gradient in water.

Crew: 6 men
Mission: Oceanography.

Design: 1964-1966 by Picard.

Why the Gulf Stream?

Boat temp. 1°C greater than water temp., no power for heating - needed warm water.

Why more + to see more volume of ocean.

Gulf Stream studied well already - opportunity to integrate their data

WORKING PAPERS

~~Geomorphology~~
Li Se Sciences

Two Sea-Scaphs collected data
in parallel with Ben Franklin.

INSTRUMENTS ON BEN FRANKLIN:

Temp.

Salinity

Speed of Sound

Light Transmission

} monitored automatically every 2 seconds
during cruise.

Gravimeter was on board too.

It will take months to reduce data. But this will be most
complete survey of Gulf Stream to date.

Li Se Sciences Studies:

Stored as Lax on board in
insulated tanks.

Pressure: 1 atmosphere, H_2/O_2 atmosphere.
20% to 21% during mission

LiOH for CO_2 removal.

Water: Hot water was heated before mission and stored aboard -
system didn't work well.

Cold water: purified by iodine treatment before
leaving. After 4 or 5 days
the cold water was contaminated by
bacteria. They stopped drinking
it, but used it for cooking.

Of the 6 crewmen 3 didn't lose weight, 2 lost weight
inadvertently, one lost weight
deliberately.

NASA Interest: Some mission duration, small crew-size.

One NASA engineer was a crewman:

EQUIPMENT:

• 3 AUTOMATIC CAMERAS 1 FRAME OF EACH PER² MINUTES DURING THROUGHOUT MISSION.

• COUNTERS ON BUNKS TO CHECK OUT SLEEP PATTERNS.

Quite similar except for zero g and radiation, to space flight.

Description of the dive itself:

Palm Beach to Hatteras - anticipated speed was 2. to 2 1/2 knots. Gulf Stream is very vigorous and laminar in this region.

North of Hatteras, eddies occur which are a hundred miles in dia.

But off Florida, speed was only 1.6 knots.

After ¹² Sunday, south of Hatteras, the Ben Franklin drifted out of the Gulf Stream.

They surfaced, and were towed to the Gulf Stream core. Hatches were not opened during this surfact period.

North of Hatteras speed picked up to as much as 3 knots contrary to expectations max. speed was 4 knots. average per day. during 5 or 6 hour period. Say 4.5 knot speed. This has been calculated, but never observed before.

Depth:
200 meters.

WORKING PAPERS

3 knots speed was maintained.

Normal 24 HOUR CYCLE
Some worked

Free schedule.

8 HRS/DAY SLEEP FOR ALL CREWMEN,
most 5 hrs to 5 day spent working.

PICCARD PERSONALLY KEPT TO A 24 HOUR DAY, SLEEPING AT NIGHT, WORKING DURING THE DAY. SOME CREW MEMBERS CHOSE TO WORK AT NIGHT AND SLEEP DURING THE DAY. VISUAL CLUES: THERE WAS FAINT AMBIENT DAYLIGHT VISIBLE BUT NOT MUCH. WORK SCHEDULE DID NOT EXIST; EACH MAN SET HIS OWN DAILY SCHEDULE FOR HIMSELF. ~~AT~~ EACH MAN ~~WOULD~~ HAPPENED TO SLEEP ABOUT 8 HOURS/DAY. ~~THE~~ ESSENTIALLY ALL ~~WAKING~~ WAKING TIME WAS SPENT WORKING (HOWEVER SOME TASKS WERE LOOKING OUT THE PORTHOLES, OR READING DURING AUTOMATIC DATA RECORDING.)

2 people were awake at the same time, at all times. Boat was checked carefully everywhere every 4 hours. Decisions of few disagreements, and those were resolved readily. Consensus decisions were the rule. Decision to surface off Hatteras was initiated by surface crew with concurrence of Ben Franklin crew.

CREW SPIRIT WAS EXCELLENT - GOOD CAMARADERIE.

RESPONSIBILITIES OF INDIVIDUALS WERE NOT CLEARLY ENOUGH DEFINED.

THERE WAS A VERY PRECISE WATCH AGREEMENT AT START OF MISSION BUT WAS NOT ADHERED TO.

13
1 FRAMES/2 MIN = 30 FRAMES/HR * 24 = 720 FRAMES/DAY * 30 DAYS = 21,600 FRAMES / CAPERS
OVERMISSION

Food: Monotony was a problem - need more variety.

Health: A few colds among crew at beginning of mission, no other health problems.

CO problem: never over 45 ppm. (there was no cigarette smoking above during mission)
but was continuously increasing.

Only one match was lighted during mission, on Aug. 1, 1969 to celebrate Swiss independence holiday.

Time was long - they started counting the days the second day out, but they could easily have gone on a few more weeks.

Capt. } "CREW"
Pilot }
Piccard }
Ken Hogg
Chester May.
Crewman was on M.D.

THERE WERE NO OCCASIONS OF SQUABBLES OVER RESOURCES SUCH AS ELECTRICAL POWER.

ATMOSPHERE: TRACE ACETONE
" HYDROLINE - SOURCE UNKNOWN
No problem with CO₂ control. (PCO₂ never over 1%)

WORKING PAPERS

SILICA GEL was used for humidity control - was
maintained between 75% and 80%.

Analysis

{ CO
CO₂
Acetone
:

WORKING PAPERS

DOGAN: DEEP SUBMERGENCE VEHICLES

A "DEEP SUBMERSIBLE" VEHICLE IS ONE CAPABLE OF OPERATING AT DEPTHS GREATER THAN 600. FT.

TECHNICAL CHALLENGES:

MATERIALS

- FOR HULL
- FOR BUOYANCY (GASOLINE, ETC.)
- 230. to 35 #/ft³ present state of the art.

POWERPLANTS

FUEL CELLS
BATTERIES
FUEL CELLS } STATE OF THE ART

NUCLEAR - BAD BECAUSE OF RADIATION SHIELDING WEIGHT PENALTIES

INSTRUMENTATION

ACOUSTIC IMAGING SYSTEMS ARE DESIRABLE, BUT NOT YET STATE OF THE ART.

DSRV:

DEEP
SUBMERGENCE
RESCUE
VEHICLE

50' LONG, 8' DIA.

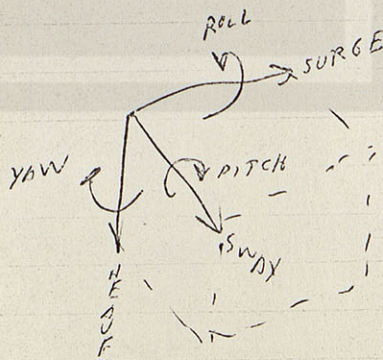
INTEGRATION & GUIDANCE DONE BY MIT.

THE CREW OF

MISSION: TO RESCUE UPSUB. ON THE BOTTOM WHICH IS TILTED UP TO 45° AND IS IN UP TO A 1-KNOT CURRENT. AT DEPTHS TO 20,000. FT.

POSITION HOLD ERROR: ± 1. INCH

ATTITUDE ERROR: 2°



WORKING PAPERS

CHUCK BERRY (MISC/INTRO): MANNED SPACE FLIGHT MEDICAL OPERATIONS

Ask Berry about prospects for a 23 1/2 hour day.
CANCEL NIXON'S ^{April 11?} DINNER WITH ASTRO!

MEDICAL OPERATIONS: - DIFFICULT TO DRAW THE LINE BETWEEN OPERATIONS AND RESEARCH. → ACTIVITIES NECESSARY TO SUPPORT MAN IN SPACEFLIGHT ACTIVITIES:

PREPARATION FOR FLIGHT
MONITORING DURING FLIGHT
RECOVERY & DEBRIEFING
DATA ANALYSIS AND INTERPRETATION

CREW SELECTION FROM MEDICAL VIEWPOINT ^{plus} _←

ORIGINAL GOAL OF MEDICAL OPERATIONS OFFICE!

DIFFICULTIES OF A MEDICAL ORGANIZATION OPERATING WITHIN AN ENGINEERING ORGANIZATION:

1. THERE IS AN INHERENT ANTAGONISM BETWEEN "FLIGHT SURGEONS" AND PILOTS OR ASTRONAUTS. (MAY HAVE THE POWER TO GROUND PILOTS OR ASTRONAUTS AND IN EFFECT "PULL THEIR DIPLOMA OFF THE WALL").

BERRY'S VIEW: MEDICAL GOAL IS TO KEEP EVERYONE FLYING; A GROUNDING A MAN FOR MEDICAL REASONS IS A "FAILURE OF PREVENTIVE MEDICINE".

2. PUBLICITY ASSOCIATED WITH SPACEFLIGHT AND THE CREWS MAKE A GOOD DOCTOR-PATIENT RELATION DIFFICULT: A PROBLEM DURING THE FLIGHT - EVEN A HEADACHE - MAKES HEADLINES AROUND THE WORLD, WITH POSSIBLE IMPLICATIONS FOR THE FUTURE OF MANNED SPACEFLIGHT. BERRY WOULD LIKE TO SEE SOME CENSORSHIP OVER ~~THESE~~ INFO THAT GETS TO NEWS MEDIA IN REAL TIME.

3. LOVEMAN'S ATTITUDE ABOUT PHYSICIANS: ENGINEERS VIEW MEDICS AS CONSTRAINING THEIR DESIGNS. BERRY PREFERS NOT TO GIVE OUT NUMBERS FOR DESIGN PURPOSES, BUT RATHER TO SIT DOWN AND GIVE THE DESIGNERS SOME

WORKING PAPERS

UNDERSTANDING OF THE MEDICAL PROBLEMS.

CCB
BOARD
DISCUSS
MISSION- JUST LIKE THE APES DANCING AROUND THE ORECKIN IN THE MOVIE 2001.
A SPACE ODYSSEY.ATMOSPHERE CHANGE FROM PURE O_2 ON THE PAD TO 60% O_2 / 40% N_2
ON THE PAD.

FOOD, WATER, WASTE MANAGEMENT.

- MISSION PLANS:
1. PRELIM. PLAN
 2. REF. MISSION
 3. MODIFICATIONS OF REF. MISSION
 4. FLIGHT PLANS WORK/REST CYCLES } MEDICAL REVIEW
 MEAL PERIODS OF THESE.
 5. MISSION RULES
- ANSWER THE QUESTIONS: "WHAT IF...?"

REQUIREMENTS FOR RECOVERY OPERATIONS:

MEDICAL COVERAGE ON VESSELS

EQUIPMENT TO BE PREPOSITIONED.

MEDICAL REQUIREMENTS DOCUMENT IS PUT
TOGETHER FOR EACH APOLLO MISSION.

SIMULATIONS:

MEDICAL BRIEFING FOR CREW 30 DAYS PRIOR TO LAUNCH TO
EXPLAIN PRE-FLIGHT, IN-FLIGHT, POST-FLIGHT MEDICAL
OPERATIONS. MEDICAL EXAM SCHEDULE:

15 - COMPREHENSIVE EXAM
5 " "
5 DAILY CHECKS
FLIGHT MORNING 6

POST FLIGHT:
DAILY CHECKS

5 DAY COMPREHENSIVE CHECK
20 " "

WATER PURIFICATION:

WORKING PAPERS

CHLORINE IN C/M POTABLE WATER SYSTEM (CHLORINATION SCHEDULE FOR TAFLED)
IODINE IN L/M POTABLE WATER SYSTEM - ONE SHOT, PRE-FLIGHT SINCE
ALL WATER IS PRESENT
AT START OF MISSION.

WASTE MANAGEMENT:

ONLY ARCHaic, PRIMITIVE SYSTEM FLYING AT PRESENT.

APOLLO 11 MISSION:

APOLLO 7, 8, 9 HAD PRE-FLIGHT ILLNESS, IN-FLIGHT ILLNESS, AND
POST-FLIGHT ILLNESS: VIRAL, GASTROINTESTINAL (NAUSEA, VOMITING),
~~RESPIRATORY~~ (COPING).
~~BRONCHITIS~~

APOLLO 10, 11 HAD PREVENTIVE MEDICINE PROGRAMS. A/SG SEASON
OF 5 YRS WAS HELPFUL SINCE VARIOUS VIRAL DISEASE
WAS NOT PRESENT.

NO ILLNESS DURING 21 DAY PRE-FLIGHT PERIOD, NOTHING
IN-FLIGHT OR POST-FLIGHT IN APOLLO 10, 11.

SLEEP: APOLLO 10, APOLLO 11 CREWS SLEPT WELL ON WAY TO
MOON. Did not sleep well in L/M on Lunar
SURFACE: IT GOT COLD IN L/M ON SURFACE - THEY
SHIVERED WHICH COULD BE SEEN FROM THE
GROUND. They didn't take any sleeping pill on
SURFACE.

19
VESTIBULAR PROBLEMS SINCE APOLLO 8: SURFICIT HINGERS
HAD FREE VOLUME TO STAY AROUND. Mild
STOMACH AWARENESS TO AUSEA VOMITING IN 5
AT 5 G CREWMEN ON APOLLO 8, 9.

Head movements suggested by Pensacola rotating room
data was not effective on Apollo 10.

CREWS HAVE ADAPTED WELL OVER FIRST VISIT TO
VESTIBULAR DIFFICULTY. No vestibular problems on
Apollo 11 & 11.

Lunar dust is "greyish talcum powder".

Prophylactic surgery on 6 mo. or more missions: Feeling is little likelihood of needing evidence at the moment but we'll do this. Will check strongly for incipient gall bladder problems for example.

On Palfis patrols: gall bladder problems more common than appendicitis.

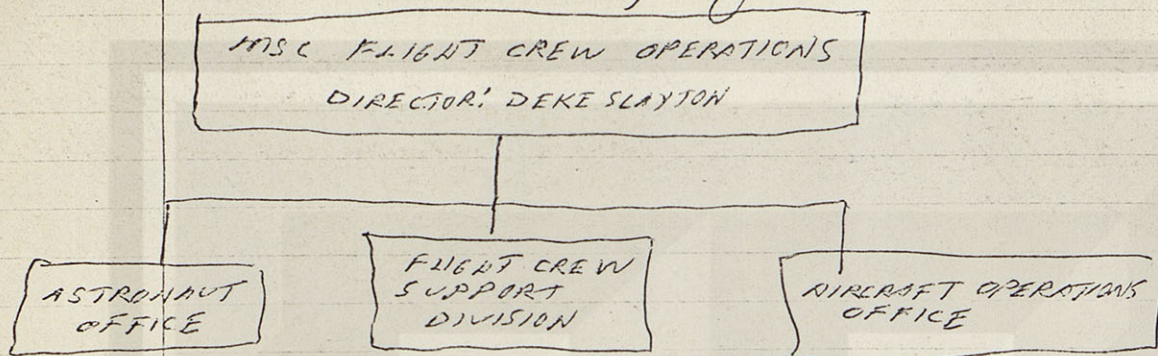
There is not presently a predictive technique for vestibular disturbance from water in space.

proprioceptive inputs: clothing weight, pressure distribution as well.

There was a good deal of lunar dust tracked into the LM on Apollo 11. In orbit the dust kept stuck to the floor, didn't float free in air.

ASTRONAUT JOSEPH KERWIN, M.D. : CREW OPERATIONS

Working closely with AAP



MSC FLIGHT CREW OPERATIONS MISSION RESPONSIBILITIES:

- TRAINED CREW
- FLIGHT PLAN
- OPERATIONS HANDBOOK
- SUPPORTING SPACECRAFT CHECKOUT
- PROCEDURES AND CHECKLISTS
- CREW ASSOCIATED FLIGHT EQUIPMENT (EXPERIMENTS, CANNERS, ETC.)
- CAP COMBAT (TRADITIONALLY AN ASTRONAUT)
- FLIGHT CREW SCR

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REAL TIME CHANGES TO FLIGHT PLAN.

Hardware responsibility is an anomaly in the organization that just grew up.

CREWS ARE THEORETICALLY SELECTED 9 or 10 MONTHS BEFORE A FLIGHT.

(SPACE SUITS TAKE 3 MONTHS TO BUILD AND ARE NEEDED FOR TRAINING 6 MONTHS PRIOR TO FLIGHT.)

WORKING PAPERS

WORKING PAPERS

PHYSICAL TRAINING 5 HRS./WK
 AIRCRAFT FLYING 200 HRS./YR.
 ADMINISTRATIVE 4 HRS./WK
 FLIGHT PLAN, MISSION REVIEW 5 HRS./WK
 SYSTEMS BRIEFINGS
 SPACECRAFT TESTS
 SUIT FIT & CHECKS
 MOCKUP/STOWAGE PROCEDURES
 CENTRIFUGE TRAINING
 DCPS/LAUNCH VEHICLE TRAINING
 CSMA SIMULATION
 RENDEZVOUS DOCKING SIMULATION (LRC)
 PLANETARIUM
 LM SIMULATION
 WEIGHTLESSNESS OPERATIONS (AC)
 LUNAR LANDING TRAINING VEHICLE
 PARACRESS PRACTICE

APOLLO MISSION SIMULATOR ← MAIN TRAINING TOOL.

PHYSICAL EXAMS
 MEDICAL EXM. BRIEFINGS
 CHECK EFFECT OF DRUGS IN MED. KIT ON THE INDIVIDUAL CREW

CONTINUING ASTRONAUT PARTICIPATION IN EQUIPMENT design.

→ MSC-00016, "MEDICAL REQUIREMENTS, G TYPE
 MISSION, LUNAR LANDING", MSC, JUNE 1969.
 Write to C. D. BERRY Son this - he's
 agreed to send one to all 11 of us.

WORKING PAPERS

CREWS HAVE WITHOUT EXCEPTION SLEPT WELL THE NIGHT BEFORE LAUNCH WITHOUT SEDATION, BUT AT CREW'S DISCRETION A DRINK WITH MEALS WAS TAKEN.

BETWEEN 14 AND 30 DAYS PRIOR TO FLIGHT, THE BACKUP CREW ACTIVITIES CEASE TO PARALLEL THE PRIME CREW'S ACTIVITIES; THEREBY THE BACKUP CREW IS CONVERTED ESSENTIALLY TO A SUPPORT GROUP FOR THE PRIME CREW.