ULTRA-VIOLET RAYS AND THEIR VALUE

IN

THERAPEUTICS.

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D.Paterson Leiper.

I933.

INDEX.

CHAPTER (III).

Introduction & Historical Outline.

The introduction of Ultra-Violet rays to the realms of Medicine is of comparatively recent date.
Results of thirty years' intensive research on U.-V.therapy can be seen in its successful application in a wide variety of diseases:in fact,the value of this form of treatment has been so clearly demonstrated that it must now be regarded as an indispensable part of modern therapeutics.

During the past three years the writer has used U.-V.rays in the treatment of 270 cases,about I,700 treatments having been given: the results have been so highly satisfactory that he proposes to add his experience to the ever-growing evidence in favour of this remarkable therapeutic agent.
Since the cases have been of a general nature,one has had no opportunity of specializing in any one particular branch:the results,however,demonstrate the usefulness of Ultra-Violet rays in general practice.

In the course of this thesis one will show that the activities of radiations are not the result of haphazard occurrences:it will be clearly demonstrated that definite principles are involved in the production of profound beneficial effects on the organism.
One will explain his conception of the biological activity of the rays in the synthesis of vitamins in the skin,in the production of pro-hormones,and in the regulation of the various metabolic processes of the body:this will involve descriptions of the different bodily elements in their chemical activities and inter-activities.

The following is an outline of the principal discoveries affecting the development of apparatus for the artificial production of Ultra-Violet radiations:

I666: Newton's experiments with the prism led to his discovery of the visible spectrum: this opened the gateway to the field of radiant energy.

I678: Christiaan Huygens enunciated the wave-theory of light, the assumption being that a universally diffused medium undergoes some regularly repeated physical change.

I733: Dufay discovered that there are two kinds of electricity.

I774: Fauré treated ulcers with solar rays, this being supplemented later by the use of focussing lenses.

I777: Scheele, by projecting the visible spectrum on silver chloride, produced metallic silver, with liberation of chlorine, in the region of the Ultra-Violet rays.

I779: Ingenhouse showed that it is the light and not the heat of the sun that enables the chlorophyll of the plant to dissociate CO_2.
Volta announced his discovery of the voltaic battery.

I800: Herschel discovered the infra-red region by means of a delicate thermometer.

I80I: Ritter, working on the lines adopted by Scheele, discovered the presence of radiations beyond the violet end of the visible spectrum.

I802: Davy, by his discovery of the electric arc, made artificial ray therapy possible.

I809: Gay-Lussac and Thenard observed the various reactions of chlorine and hydrogen to the influence of light.

I8I5: Planché investigated the action of light on many metallic salts.
Fraunhöfer discovered dark lines in the solar spectrum.

I820: Grotthus enunciated the photo-chemical law of absorption, stating that "only the rays absorbed are effective in producing chemical change".
Lambert's (Cosine) law, complementary to this, stated: "The proportional part of the light which is absorbed by any absorbing medium is independent of the intensity of the incident light, but varies with the angle of incidence".
The gist of Draper's elaboration of this law is that certain hues are decolourized by others, each being attacked by the colour complementary to its own.

Oersted showed that a magnetic field is created round a wire connecting the two terminals of a voltaic battery.

I830: Niepcé and Daguerre introduced the first practical process of photography, thus making possible the accurate recording of the various regions of the spectrum.

I83I: Faraday found that an electric current is created in a wire loop by moving a magnet towards or away from it: this discovery led to the construction of the dynamo.

I837: Chevreul noted the influence of air and moisture, in conjunction with sunlight, in the bleaching of vegetable colours.

I845:Bonnet demonstrated the beneficial effects of locality and generally applied heliotherapy in cases of tuberculous osteo-arthritis.

I854:Bunsen perfected the spectroscope.

I862:Foucault and Fizeau devised an experimental method of determining the velocity of light.

I865:Maxwell predicted the existence of electro-magnetic waves or vibrations in the ether by enunciating the wave-theory of light.

I868:Angstrōm mapped out the wave-lengths of the visible solar spectrum:his unit represents a ten millionth of a millimetre.

I873:Vogel made a great advance in photography by his introduction of certain dyes to increase the spectral range of sensitiveness of silver salts.

I876:Rowland discovered that if an electrified body is moved a magnetic field is created round it.

I877:Downes and Blunt demonstrated the abiotic action of light.

I879:Crookes discovered cathode rays while experimenting with a vacuum tube excited by a high-tension source of electricity.

I885:Michelson estimated the velocity of light to be I86,326 miles per second.

I886:Hertz verified Maxwell's theory as to certain electric waves much greater in wave-length than the longest infra-red waves which had been measured:by means of his oscillator he discovered that electro-magnetic waves can be produced in the ether with all the fundamental properties of light waves, but differing from them in wave-length,frequency,and penetrating power.

I889:Widmark showed that erythema and pigmentation are caused by the Ultra-Violet rays in sunlight.

I890:Palm called attention to the effect of sunlight in the treatment of rickets:calling it a disease of darkness,he suggested that other diseases of malnutrition might also be due to lack of sunshine.

I893:Finsen demonstrated that sunburn was a reaction of the skin to the actinic rays in light,and that these rays belonged to the U.-V.portion of the spectrum;he also showed that their penetrative power was small.
The publication of his results in the treatment of lupus with the carbon arc led to the installation of apparatus of this type in The London Hospital.

I895:Roentgen discovered the X-rays,these being held to be of extremely short wave-length.

I896:Becquerel discovered the phenomenon of radiography.

I897:Thomson showed that the cathode rays discovered by Crookes were made up of particles of negative electricity called electrons.

I898:Madame Curie and Schmidt,working independently,discovered the radio-activity of thorium.In the continuation of her researches into the radio-activity of uranium,Madame Curie made the discovery that certain samples of pitch-blende (oxide of uranium) exhibited greater degrees of radio-activity than others:this unusual circumstance led her,in conjunction with P.Curie and G.Bemont,to attempt the separation of the chemical elements of this ore.

Three radio-active substances were discovered--polonium, radium.and actinium,the last-named being discovered by Debierne in this same pitch-blende;it is more powerful but less easily obtained than radium.

I90I:Hewitt(who used thallium and caesium in the construction of quartz mercury arcs to increase output of U.-V.radiations) discovered that U.-V.rays capable of passing through a quartz lamp could be produced by the quartz mercury-vapour arc. This discovery did much to bring Ultra-Violet ray therapy into everyday use.

I902:Bernhard was the first to use natural sunlight in the treatment of surgical wounds:his experiments were carried out at Samaden in the Engadine.

I903:Rollier instituted his system of treatment by natural sunlight:his work gave a great impetus to the development of treatment by both natural and artificially produced light.

I904:Kromayer invented the water-cooled quartz mercury-vapour lamp for local treatment.
Ramsey and Hahn, radio-thorium.

I906:Boltwood discovered ionium.

I908:Gauvain introduced heliotherapy at Alton.
Nagelschmidt used the air-cooled quartz mercury-vapour lamp for general irradiation of the body.

I9II:Bardenheuer began experiments at Cologne in the conservative treatment of surgical tuberculosis.

I9I3:Reyn employed the carbon arc in general treatment.

I9I8:Huldschinsky was the first to demonstrate the effects of U.-V.rays on the bone lesions in rickets.

From I9I8 until the present time much research work has been carried out on the subject of Actinotherapy,Hill,Eidinow,Gauvain, Chick,Hess,Weinstock and Steenbock,and many others having contributed greatly to the advancement of this new science. Improvement in apparatus and technique has also done much to bring U.-V.therapy to its present state of high efficiency.

CHAPTER IX.

Apparatus.

Since the various types of Ultra-Violet ray apparatus are fully described in the text-books on Actinotherapy,only brief mention need be made of them here:

Ultra-Violet rays are produced by the passing of an electric current between two terminals of special material,the arc formed giving out an intense illumination consisting of U.-V."cold" and visible rays.
In quartz lamps heat generated as part of the incandescence is absorbed by the arc tube and re-radiated.
There are two main types of arc:

I.ENCLOSED----Mercury Vapour In Quartz Tube.
a.Air-cooled:
b.Water-cooled.

2.OPEN. ----Solid Electrodes.
a.Carbon--Plain or Cored:
b.Iron:(Seldom Used).
c.Tungsten.

a.Air-cooled (British Hanovia).

The quartz lamp for general treatment has been greatly improved recently,an entirely new type of hood having been designed,and a rheostat fitted:a new type of burner adds to the general improvement in efficiency,high U.-V.output being maintained for about a thousand hours...approximately 28%.
At a distance of forty inches one is able to induce a first degree erythema in the unpigmented subject by one minute's exposure.
The revolving hood,with its mirror-surfaced stainless steel reflectors set in different planes,enables one to focus the rays on any desired part of the body,while there is very little loss of energy from lateral deviation.
One has been using a silenium cell to test the output of the lamps

Having experimented with various types of technique,one has come to the conclusion that irradiations should not be given more often than once a week:the results seem to be better with weekly moderate doses.
The number of treatments depends on the nature of the condition, simple anaemias,for instance,clearing up completely after six weekly exposures:chronic mild pulmonary tubercle is usually cured by 24 treatments.
One usually irradiates patients at forty inches on the first occasion,gradually reducing the distance to twenty eight inches.
The time of exposure is increased by two or three minutes each time,depending on the patient's reactions.

b.Water-cooled---Super-Kromayer.

This lamp is of great value in the treatment of diseases affecting the skin and mucous membranes.By means of compression lenses and quartz applicators,the rays can be conveyed to the deeper layers of the skin and to the various orifices of the body respectively.Such conditions as parasitic skin affections,chronic rhinitis,tonsillitis,cervicitis,etc.,etc.,are easily treated,the results very often being excellent.
The Kromayer lamp is of great value wherever a strong local reaction is indicated.The high efficiency is due to the distilled water being more transparent than ordinary tap water,impurities in the latter absorbing radiations to a considerable extent.

One has designed a tonsil applicator having a cup-shaped treatment-end;it is less cumbersome than the usual applicator,and irradiates the tonsil equally all round.
Various types of applicator may be designed:one believes that instruments similar to the bronchoscope and oesophagoscope could be made for U.-V.treatment of bronchitis and asthma,oesophageal ulcers,etc.;such chronic conditions might respond well to direct irradiation.

a.Carbon Arc.

The "Flaming Arc" lamp is well suited for hospital work since several patients can be irradiated at one time.The arc takes its name from the length of the flame,the gap being capable of extension to 4I/2 inches by increasing the voltage:the U.-V.output is correspondingly increased.

Electrodes usually consist of carbon "cored" with tungsten,iron, or some other metal,such treatment enhancing the output.

This arc produces intense radiation in the near region,its spectrum extending from 7,700 A.-2,800 A.

Since the writer has had no experience of the carbon arc,he is not in a position to discuss the relative merits of carbon and mercury-vapour:although the results with the quartz lamps have been very gratifying,one intends installing a carbon arc in the near future in order to combine the qualities of both.

c.Tungsten Arc.

The spectrum extends to about I,850 A.,with few absorption bands. Since the cost of tungsten is prohibitive,carbon electrodes treated with this metal are usually used.

This type of lamp shows delayed erythema.

LUMINOUS HEAT APPARATUS.

The close association of infra-red rays with actinic radiations in practice renders necessary a description of the apparatus used in their production.
One uses the I,000 watt Oeken Sollux lamp (Hanovia).It consists of a tungsten-filament bulb of 2,000 c.p.,containing nitrogen at 2/3rds.atmospheric pressure:this is mounted in a parabolic reflector to which can be attached various sizes of localizer.

This lamp is used mainly for its local hyperaemic effect,red and blue filters being used in certain types of disease:the former is used in acute weeping forms of eczema and similar conditions, while the latter produces an analgesic effect which is of value in certain rheumatic and neuralgic conditions,etc.

The spectrum extends from 8,000 A.-I5,000 A.and beyond.

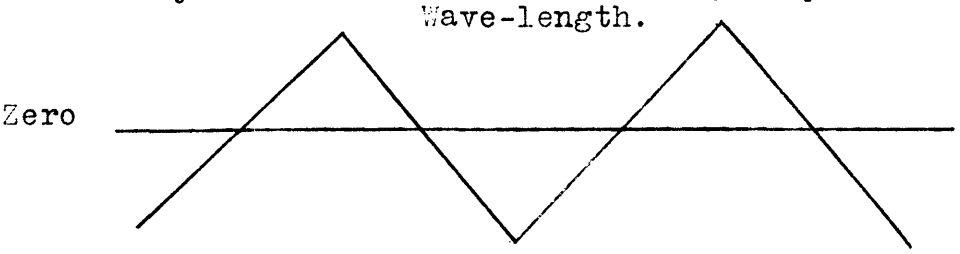
One uses this lamp principally as a preliminary to U.-V.treatment, deep congestion being induced which aids in the absorption of amino acids and other elements produced by U.-V.ray action.

It is now generally accepted that all matter is atomic in structure,and that the molecules of all known substances are formed by the combination of the atoms of the 92 elements,the disposition of their atoms determining the nature of the substance.
The splitting of the atom has resulted in the elucidation of many interesting facts concerning the physical properties of electro-magnetic radiations.

A description of the atom and its activation by electro-magnetic influences will explain many of the phenomena that occur in the ether and in the animal organism as the result of such influences:
An atom,which is the smallest quantity of an element that can exist and still retain the chemical properties of that element, consists of a nucleus--proton and electrons positively charged, the amount of the charge corresponding to the atomic number of the atom--and systems of negative electrons revolving round it in various orbits.
Electrical balance is maintained as long as the number of surrounding negative electrons equals that of the positive charges on the nucleus,the electrical state of the atom being neutral.
Many of the properties of the atom are determined by the number and arrangement of these electrons,particularly of the valence or peripheral electrons which are the most unstable and easily dissociated.

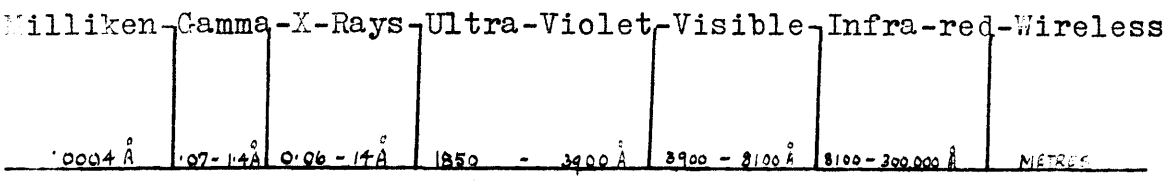
Solar emanations activate the atom,the result being either relegation of electrons to less stable orbits,or ionization of the atom,one or more valence electrons being removed;in some cases almost complete stripping of orbital electrons occurs.
The atom,agitated by the attempts of electrons to recover their equilibrium,combines with other atoms to form molecules,the electrical force or energy causing and maintaining such changes being called chemical affinity.
Dissociated electrons are taken up by other atoms which have become ionized;in some cases they may return to their own atoms.
Since the amount of energy emitted during activation of the atom is commensurate with the proximity of the orbital electrons to the nucleus,the wave-length of the radiation will depend on the orbit disturbed;that is,- the longer wave-lengths result from displacement of inner orbits,and the shorter wave-lengths from disturbance of valence electrons.
One is of opinion that a definite wave-length of solar emanation finds its affinity in one particular orbital system,where it produces its specific effects.
Every atom--each has its own definite rate of vibration--will emit one or more colours,the number depending on the number of orbits involved,and also on its temperature,since the spectral lines emitted by a substance are characteristic of it at a given temperature.If an element is visible,its colour is determined by the wave-lengths,and its brightness by the amplitude;from these the rate at which the atom is oscillating can be ascertained.

Rapidly alternating electro-magnetic fields result from this oscillatory state produced in electrons,atoms,and molecules,the jerky emission of energy propagating waves of radiation straight outwards in every direction from the oscillatory body at a uniform speed of approximately 186,360 miles per second.
The oscillations or vibrations are transverse to the direction in which they are propagated,while their frequency --the rate at which one wave follows another --varies inversely with the wave-length:the amplitude of the oscillations is the highest point reached by them above or below an imaginary zero.



The natural phenomenon of colour fusion to form white light can be reversed by allowing a ray to pass through a prism, when it will be analysed into its constituent spectral colours or atomic emissions: quartz prisms are necessary in the study of Ultra-Violet radiations.

Range of Electro-magnetic Radiations.



In this country the recognised unit for the designation of wave-lengths is the Angstrom (Å) : it has been arbitrarily fixed as the wave-length of the softest X-ray, and represents I/IO mth.m.m. Other units sometimes employed are the Millimicron--I mth.m.m., and the Micron--I/I,000th.m.m.
There are also three methods of dividing the Ultra-Violet range into regions:

A. NEAR (4,000-3,000Å.); FAR (3,000-2,000Å.); EXTREME (2,000-360Å.).

B. ULTRA-VIOLET; U.-U.-VIOLET; SCHUMANN'S OR LYMAN'S BAND.

C. NEAR; MIDDLE; SHORT.

DETECTION & MEASUREMENT OF ULTRA-VIOLET RADIATION.

The presence of radiations can be detected and their intensity measured by direct and indirect methods, the former employing the radiometer, thermopile, etc., and the latter photometric, chemical, and photo-electric effects.
Crookes' radiometer consists of two blackened vanes of mica fastened to a horizontal arm which is suspended by a fine quartz fibre. Radiation falling on the vanes tends to rotate the arm, while a mirror reflects an image of the scale recording the measurement of deflection: the pressures used are a few hundredths of a m.m. of mercury.

In the photometric method a spectroscope fitted with a photographic plate is used to record the spectrum of radiation, this being compared with a spectrum of known source and strength.
Chemical methods depend on the reducing effects of radiation on certain chemicals: an example is the bleaching of an acetone methylene blue solution, comparison being made with certain standard solutions.
Photo-electric effects result when radiation falls on the polished surface of a zinc plate, negative electrons being dissociated. If a fine metallic gauze, positively charged and connected to a gold-leaf electroscope, is placed in front of the plate, the electrons will be caught and measured, the intensity being determined.

ABSORPTION OF RADIATION BY VARIOUS MEDIA.

Most substances become increasingly opaque to U.-V.radiation as the wave-length decreases,the absorption being equal to the ratio of the amount absorbed to the amount incident.
The absorption limits of many solids,glasses,liquids,and gases have been determined;the following are examples of transmission data:

Solids.

Clear,colourless fluorite has been found to be the most transparent solid,its use enabling Schumann and Lyman to penetrate the extreme region of the spectrum.A good specimen of I.5 m.m. thickness transmits wave-lengths down to I,250 Å.
The next best is pure crystalline quartz,absorption beginning at I,450 Å.
Rock-salt has a higher dispersion than the above,but transmission decreases rapidly beyond I,800 Å.

Glasses.

The amount of absorption depends on the thickness and chemical composition of the glass;consequently,absorption limits vary greatly.
Ordinary window glass absorbs rays below 3,300 Å.,while "Vita-glass" is capable of transmission down to 2,750 Å.,its properties being due mainly to the quartz in its composition.
Various glasses have been made for use as filters,only U.-V.rays being transmitted:Chance's filter is an example,allowing to pass only those rays between 2,870 Å.and 4,270 Å.,with maximum between 3,300 Å.and 3,900 Å.

Liquids.

Impurities in ordinary tap water render it more absorptive than distilled water:in a depth of IO cm.all rays below 2,350 Å.are absorbed.
Blood absorbs all rays shorter than 4,500 Å.,and shows absorption bands at 5,400 Å.and 5,750 Å.
Many experiments have been carried out with liquids,the results leading to the general conclusion that those which are fluorescent are opaque to U.-V.radiations,although there are exceptions, especially those which show only slight fluorescence.

Gases.

The transparency of air to extreme radiation is believed to depend on the oxygen content,since this gas absorbs wave-lengths shorter than I,850 Å.
Ozone absorbs rays strongly,and determines the transmission of the middle and near rays.

Skin.

Penetration by different wave-lengths depends on the depth at which their affinities are situated.The following table shows percentage of absorption of wave-lengths in the near and middle regions.
In the shorter range there is some inconsistency in the powers of radiations to penetrate the skin,these not always being commensurate with increase in wave-length.

Absorption %ages of Different Wave-lengths.(Hasselbalch).

W.-L.	4,360	4,050	3,660	3,540	3,I30	3,020	2,970	2,890
.Imm.	59	55	49	42	30	8	2	.0I
Imm.	0.5	0.3	0.08	0.02				

REFLECTION.

The degree of reflection shown by a substance is determined by the amount of absorption resulting from the excitation of fluorescence.
Most substances reflect the near and middle rays fairly well,but the extreme rays are absorbed to a great extent.
Snow-blindness is caused by the marked reflection of the shorter solar radiations by snow.
In practice one finds mirror-surfaced stainless steel to be an excellent reflector of the shorter wave-lengths.

FLUORESCENCE.

This phenomenon is exhibited under U.-V.irradiation by light-sensitizing substances.One believes that this effect is given only by photo-dynamic elements,and that it occurs at the moment when stereo-isomeric changes are affecting the sensitizers.
The rearrangement of atoms in the molecule of the sensitizer will "break" the affinity of radiations for it,with consequent repulsion of the radiations:

CHAPTER FOUR.

Chemical Properties Of Radiations.

The rearrangement of electrons,atoms,and molecules in a substance constitutes chemical change,the nature of this depending on the wave-length of the incident radiation,the temperature at which the reaction takes place,on the presence of favourable (sensitizing) or unfavourable (inhibiting) influences,and on the degree of saturation.
Photo-chemical change may involve reducing or synthetic reactions, the following being illustrative of simple and complex changes in each of these categories:

Photo-reduction.

A.Simple.

Hydroiodic acid is split up under the influence of U.-V.rays:

$$2HI \rightarrow H_2 + I_2.$$

B.Complex.

An aqueous solution of sucrose is converted into glucose and fructose,these in turn being decomposed into aldehydes,ketones, and alcohols,prolonged irradiation resulting in the formation of CO_2,CO,and H_2.

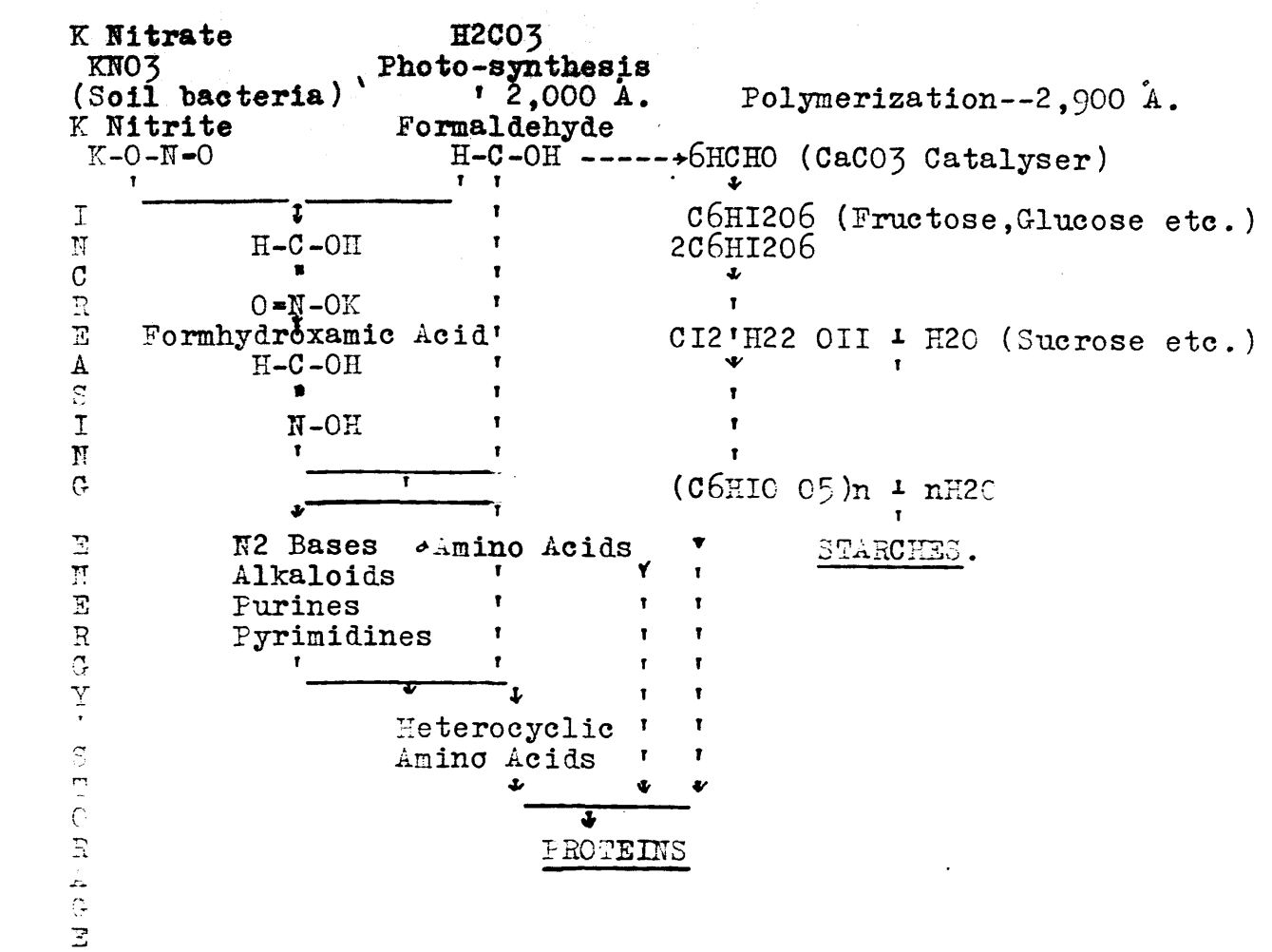
Photo-synthesis.

A.Simple.

An equimolecular mixture of dry chlorine and hydrogen can be kept in the dark without combination taking place:on exposure to sunlight,in the presence of water,hydrochloric acid is formed.

B.Complex.

The synthesis of carbohydrates,proteins,and alkaloids by the plant is an excellent example,the following probably explaining the main stages in their production:
The plant inhales CO_2 from the air,in the presence of U.-V.rays and water;chlorophyll and inorganic matter from the soil act as catalysers.



One believes that the following can explain the mode of action of U.-V.rays in producing such changes:

Before a substance can be activated by the rays,its specific sensitizing factor must be influenced,with the production in it of stereo-isomeric changes;that is to say,there is rearrangement of the atoms in its molecule,without intrinsic atomic change.This new disposition of the atoms induces electronic changes in the substance which has stereo-isomeric relationship with the sensitizer,the substance becoming activatable by its specific group of wave-lengths.
Following activation,the chemical state of the element becomes more complex,there being an increase in stored energy,and therefore an alteration in atomic and molecular distribution.
It is now susceptible to the action of still longer wave-lengths, activation by these still further increasing complexity and energy storage.
This process goes on step by step until synthesis is complete, when the electrical state will be neutral:various sensitizing elements are involved during synthesis.
The new compound will remain stable until some influence alters its electrical condition,with the initiation of reductive processes which result in graded liberation of energy.
The energizing powers of substances will therefore be commensurate with their chemical complexity.

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changes
Electro-chemical/occurring in the animal organism are analogous to those taking place in the plant;the electrical force or energy necessary for metabolism is stored in its food,liberation taking place after ingestion.The various processes involved are relatively slow in action,liable to aberration in many directions,and incur the loss of much endogenous energy.
The covering of the skin by clothes has resulted in the individual coming to rely almost entirely on food as a source of Ultra-Violet energy.

The application of artificially produced radiant energy in prophylaxis and in the treatment of diseased conditions has met with a great deal of success.In the following chapters the writer will explain his conception of the action of U.-V.rays on the organism; this will involve detailed descriptions of the various physiological processes of the body,because they are profoundly influenced by irradiation.

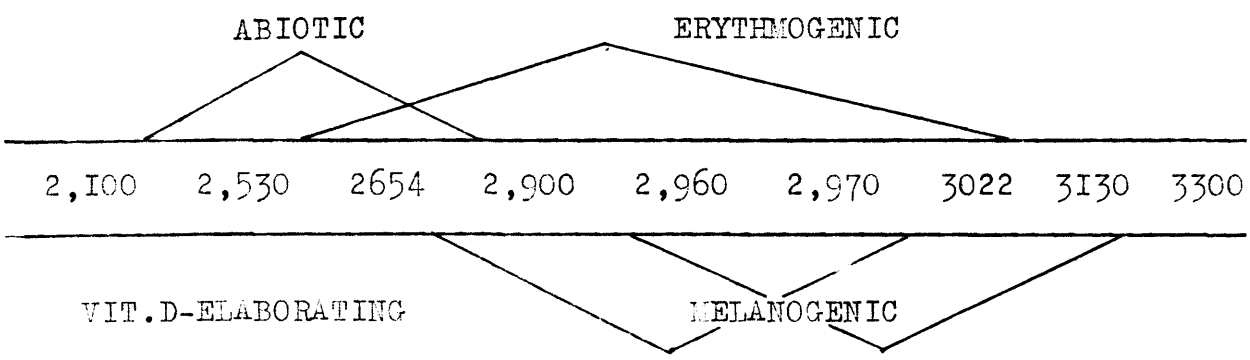
CHAPTER FIVE.

Local Biological Effects Of Radiations.

Ultra-Violet ray treatment might well be called "Radiation Shock Therapy",since it induces the parenteral introduction to the general system of elements which include powerfully activated protein and sterol bodies.That is to say,U.-V.therapy is a special protein-vitamin-shock inducer,and,as such is capable of producing tremendous stimulative effects on all the processes concerned in metabolism.

Radiations are not sectioned off according to function;rather do they form a well-balanced combination.Thus,we find the abiotic, erythmogenic,melanogenic,and vitamin-elaborating wave-lengths blending.

The abiotic radiations range from 2,I00 Å.to 2,960 Å.,with greater activity in the shorter wave-lengths:erythmogenic rays extend from 2,530 Å.to 3,I30 Å.,with maximum effect at 2,970 Å.,while those producing pigment occupy the region between 2,900 Å.and 3,300 Å.,the longer wave-lengths being the more effective.
The elaboration of Vitamin D results from activation by radiations between 2,654 Å.and 3,022 Å.



Activation by the different wave-lengths results in the production of three types of chemical change,viz.,a.molecular disintegration--affecting the protein molecule,b.stereo-isomerism--involving the various sensitizing elements,and c.molecular construction--affecting the reproductive strata,pigment layer,and pro-vitaminic substances.

MAIN FUNCTIONS OF SKIN.

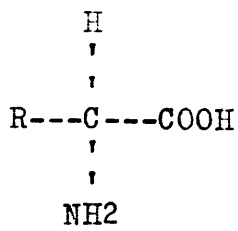
Since the skin,besides being a protective covering for the body, is intimately connected with processes of heat-regulation,waste-product-elimination,antigen-formation,endocrine-stimulation,and vitamin-elaboration,and,since it contains the receptors of the blood,lymphatic,and nervous systems,it is obvious that an upheaval in it will have repercussions throughout the body.Such an upheaval takes place under U.-V.irradiation,the cellular structure being bombarded by radiant energy of great intensity,with the induction of high-velocity electro-chemical reactions:the products of such changes are,relatively speaking,"shot" into the general system.

EFFECTS ON THE PROTEIN MOLECULE.

Certain wave-lengths of energy activate hydrolytic enzymes or sensitizers for which they have an affinity,stereo-isomerism resulting.The protein molecule is now activated by disintegrative wave-lengths,passing through the proteose,polypeptide,peptone,and amino acid stages.
Similar changes affect the protein elements in bacteria;this explains the mechanism utilized by radiations in producing abiotic effects.

Since the amino acids are destined to play a most important part in metabolism,a detailed description of their structure and chemical nature is indicated at this stage:
The amino acids which have been isolated from protein hydrolysates are a amino acids;that is,they have an amino (NH_2) group attached to the same carbon atom that holds the carboxyl (COOH) group.

General Formula.



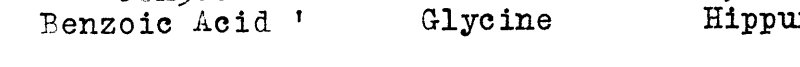
Individual amino acids differ in the character of the radical or nucleus R attached to the carbon atom.They can be classified according to the number of their amino and carboxyl groups as follows:
I.Neutral Amino Acids--containing one amino and one carboxyl grp.
2.Basic Amino Acids--containing an excess of amino groups,and
3.Acid Amino Acids--containing an excess of carboxyl groups.
Further subdivision can be made according to whether the radical R in the general formula represents an aliphatic (open chain), aromatic (closed chain),or heterocyclic (closed chain containing atoms of more than one element) type.
They are all optically active and amphoteric,ionizing both as acids and bases by virtue of their carboxyl and amino groups;they thus form salts with alkalies and acids.
Reactions due to the carboxyl and amino groups are general reactions,while those given by the radical are specific to the amino acid:the synthesis of thyroxin from tryptophane and thyroid iodine is an example of this specific reactivity.

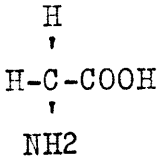
I.Neutral Amino Acids.

Solutions of these are essentially neutral;they form the largest group of the protein molecule.
A.Aliphatic.

(i).Glycine (Glycocoll) ---Amino acetic Acid. $C_2H_5O_2N$.

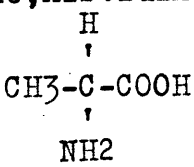
This element is used by the body as a detoxicating agent;it interacts with the carboxyl groups of toxic compounds,"splitting out" water and joining the two compounds in the following manner:



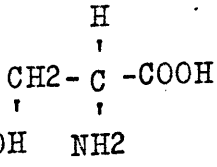


(ii).d-Alanine --- Amino propionic Acid.$C_3H_7O_2N$.

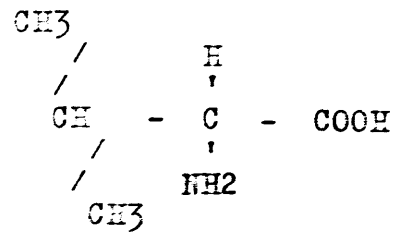
When resistant ring structures such as benzene and indol,which cannot be oxidized by the cells,are combined with alanine,they can be readily oxidized;such combinations form the important amino acids phenylalanine,histidine,tyrosine,tryptophane,etc.



(iii).l-Serine ---b hydroxy-a-amino-propionic acid/b -hydroxy-alanine.
$C_3H_7O_3N$.

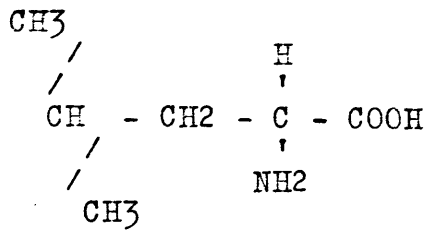


(iv).d-Valine---a-amino-isovaleric acid/b,b-dimethyl-alanine.
C5HIIO2N.

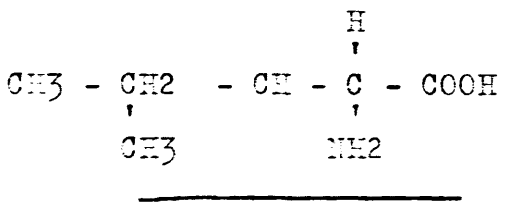


(v).l-Leucine---a-amino - isocaproic acid/b-isopropyl-alanine.

Normally present in the pancreas,thymus,thyroid,spleen,and other endocrine glands. C6HI3O2N.

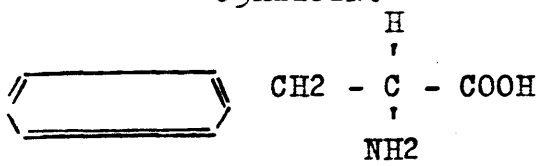


(vi).d-Isoleucine--- b-methyl-a-amino-valeric acid/b-methyl-b-ethyl-alanine.
C6HI3O2N.

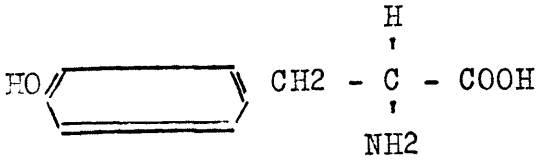


B.Aromatic Amino Acids.

(vii).l-Phenylalanine---b-phenyl-a-amino-propionic acid/b-phenyl-alanine.
C9HIIO2N.

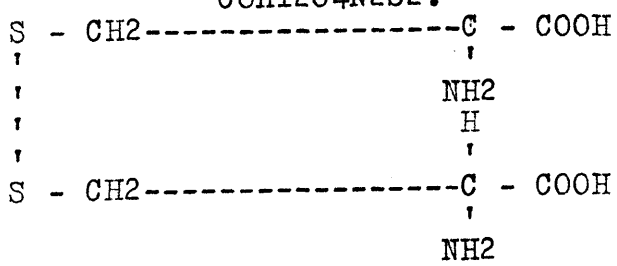


(viii).l-Tyrosine---b-para-hydroxy-phenyl-a-amino-propionic acid/b-para-hydroxy-phenyl-alanine.
C9HIIO3N.



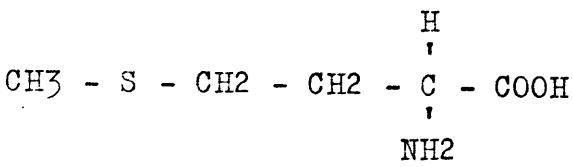
C.Sulphur-containing Amino Acids.

(ix).l-Cystine---di-cysteine/di-(b-thio-alanine).
C6HI2O4N2S2.



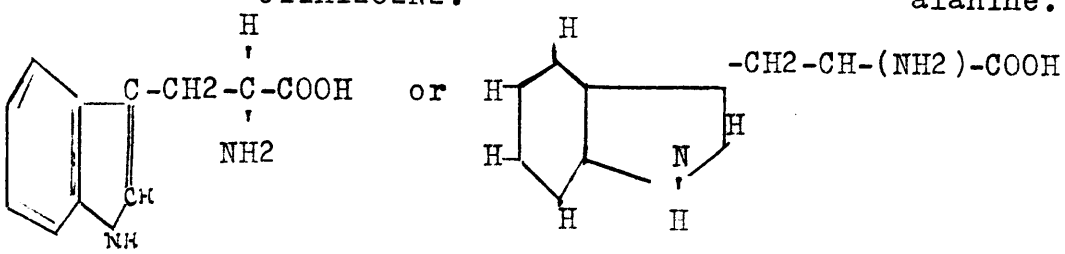
Present in greatest amount in hydrolysates of keratin-containing tissues.Cystine is concerned with glutamic acid and glycine in the formation of glutathione,an indispensable constituent of every cell.

(x).l-Methionine---γ-methylthiol-a-amino-n-butyric acid.
C5HIIO2NS.

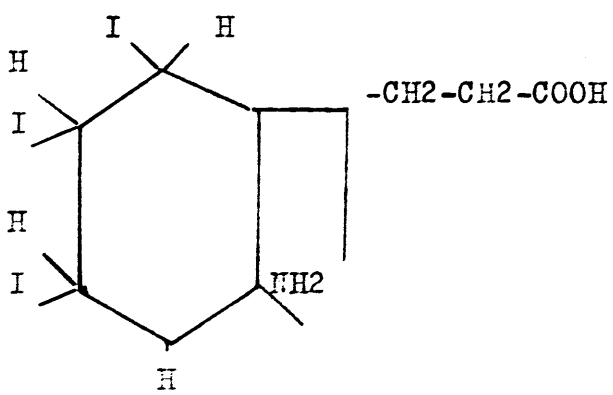


D.Heterocyclic Amino Acids.

(xi).Tryptophane---b-3-indol-a-amino-propionic acid/b-indol-alanine.
CIIHI2O2N2.

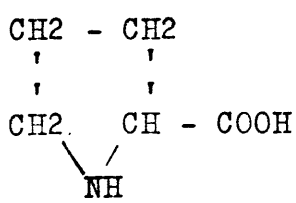


Thyroxin--Open Ring Form.

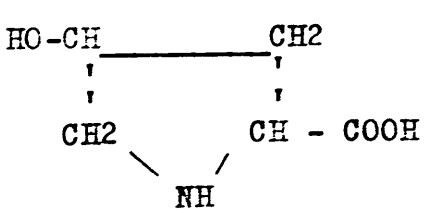


(xii).l-Proline---Pyrrolidine-2 carboxylic acid.
C5H9O2N.

Haemoglobin contains such rings as pyrrolidine.Proline forms salts with copper.



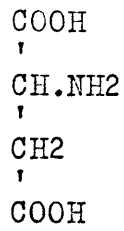
(xiii).l-Hydroxyproline---oxyproline/4 hydroxy-pyrrolidine-2 carboxylic acid.
C5H9O3N.



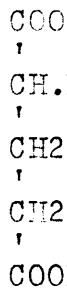
2.Acid Amino Acids.

These form insoluble calcium salts in vitro.

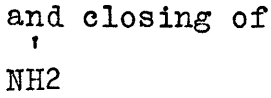
(xiv).l-Aspartic Acid---amino-succinic acid.
C4H704N.



(xv).d-Glutamic Acid---a-amino-glutaric acid.
C5H904N.

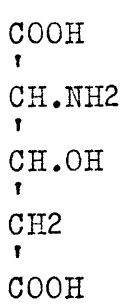


This is the largest percentage component of a single protein:it is found combined with glycine and cysteine in the glutathione molecule-glutathione being present in every cell.
COOH-CH-CH2 CH2 CO - NH-CH-CO - NH-CH2 COOH
Oxidation and reduction occur by the alternate opening and closing of SH radicals.



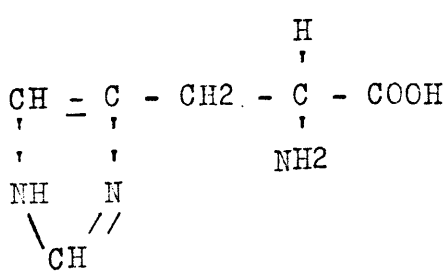
(xvi).d-Hydroxyglutaric Acid---b-hydroxy-a-amino-glutaric acid.

C5H905N.

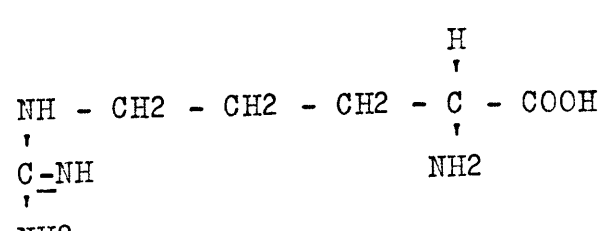


3.Basic Amino Acids.

(xvii).l-Histidine---b-imidazol-a-amino-propionic acid/b-imidazol-alanine.
C6H902N3.

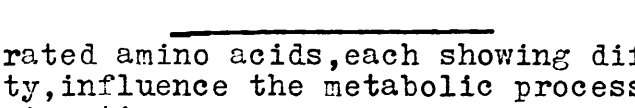


(xviii).d-Arginine---d-guanidine-a-amino-valeric acid.
C6HI402N4.



Arginase of the liver splits arginine into urea and ornithine(a-d-diamino-valeric acid).
In certain metabolic disturbances guanidine is split off;this will be described later.

(xix).d-Lysine---a-ε-di-amino-caproic acid.
$C_6H_{14}O_2N_2$.



The liberated amino acids,each showing different electro-chemical reactivity,influence the metabolic processes going on in the neighbouring tissues.

Effects of Radiation on Nerves.

I.Amino Acid Influence--Indirect.

In the process of absorption,the amino acids induce metabolic changes in the nervous papillae of the corium;vaso-dilatation results,engorgement of the parts facilitating absorption of the amino acids.

ERYTHEMA.

The stage of engorgement or erythema is reached in from I-8 hours after effective irradiation,its time of appearance,intensity,and duration depending on the extent of the disintegrative changes, and on the sensitivity of the individual,the latter factor determining the velocity of the reactions.
Microscopically---about thirty hours after irradiation---no obvious changes are seen in the cuticle;the eleidin granules of the S. Granulosum,however,have almost entirely disappeared,while vesiculation and leucocytic emigration have occurred.
In the S.Mucosum the cells are separated by lymph,and vescicles surround their nuclei.Grouping of pigment granules round the actively dividing cells of the S.Germinativum has also occurred.
The capillaries,which have dilated to about four times their normal size,are the site of circulatory stagnation:active diapedesis takes place from the non-thrombosed vessels,and there is considerable oedema,while phagocytes remove thrombi from the superficial vessels.
When exudation is sufficiently great,the cuticle is seen to be separated from the S.Granulosum (vesciculation).

Two or three days later,the eleidin granules and the nuclei of the "prickle" cells have disappeared entirely,while the cuticle shows thickening;desquamation of this occurs when the various processes have subsided,the skin recovering its former appearance.

The above changes demonstrate phases in the processes of cell-damage and cell replacement,the latter being effected by each stratum replacing the one above it:so that the S.Granulosum replaces the cuticle,the Mucosum the Granulosum,and the Germinativum the Mucosum,these changes developing simultaneously.
The engorgement of the capillaries accelerates the process of tissue repair,besides excercising decongestive effects on underlying structures.

2.Direct Effects of Radiations.

a.Anti-Kamnic.

Analgesic effects often become apparent during irradiation;that they are not due primarily to decongestive effects is shown by the rapidity of onset.Pain may be relieved before the occurrence of hyperaemia,thus showing that certain wave-lengths are capable of penetrating to the nerve-endings where they produce direct effects.
In gastralgia,for instance,pain may be referred to the skin overlying the stomach,a zone of hyperaesthesia being produced:this reflexly induced hypersensitivity of the skin may be directly affected by the occurrence of photo-electric effects in the region of the nervous papillae,these inhibiting the transmission of painful stimuli.
Such analgesic effects may be maintained by the secondary decongestive effects resulting from erythema.

One has seèn acute indigestion and other painful conditions clear up during irradiation,even in spite of scepticism on the part of the subject.

b.Anti-spasmodic.

The prompt relief often obtained during the treatment of asthmatic patients also demonstrates direct effects on the vegetative nervous system.

c.Anti-hyperpietic.

In incipient arterio-sclerosis one has demonstrated an appreciable fall in systolic pressure a few minutes after irradiation.

Effects of Radiation on the Basal Layer.

Pigmentation.

During the regenerative phase which succeeds the first response of the cells to light stimulation,deposition of pigment occurs in the basal layer.This activity does not become apparent until several exposures have been given,thus showing that various preparatory processes come into operation after the first irradiation.

Melanin,one believes,is a complex element consisting of hormones, which have been elaborated from amino acids in the endòcrine glands,and the cells of the pigment-producing layer.
The synthesis of melanin is both a protective and a conservative gesture on the part of the organism.Pigmentation comes about in this way:
Under the repeated influence of radiations,pigment-producing granules,hormones,and oxydasic enzymes are mobilized in the basal layer:certain vitaminic elements in the blood activate the enzymes by the liberation of energy,stereo-isomerism resulting.
A synthetic process is initiated by this sensitization of the elements to activation by the longer wave-lengths of energy.
The increase of amino acids in the blood which followed erythema decreases with the onset of pigmentation:the sulphur-content of pigment is due to the presence of cystine and methionine.
This new synthetic product is disposed round the upper margins of the cells in the basal layer.

Function of Pigment.

I.The function of pigment is manifold.In the first place it acts as a protective screen to the vital layer of the epidermis with its contained reproductive,circulatory,and nervous elements:this is shown by the necessity for increased dosage after pigmentation has occurred.
In the performance of this function,pigment seems to have the property of converting the absorbed radiations into heat;this heat stimulates the sweat glands and makes the skin damp,evaporation taking place with consequent loss of heat.In this way pigment will act as a protective heat-regulator under unfavourable external conditions.
Negroes perspire at a lower temperature than Europeans because of their large amount of skin pigment.

2.Since,as will be shown later,the amino acids are the pro-hormones,and,since the hormones are capable of exerting antigenic effects,it will be seen that pigment is a store-house for substances of vital importance to the organism.
The rate of depigmentation will therefore depend on the urgency of the body's need for such elements.
One is of opinion that each of the stored hormonic substances will,by virtue of the reactivity of its contained amino acid/s,be antigenic for a specific type of infection,or for a definite group of infections;it will also exert detoxicating effects on certain products of auto-intoxication.

Pigment also excercises a direct "antiseptic" effect on the skin;

this is demonstrated by the low incidence of boils,acne,and other skin affections in black tribes.One has proved this with regard to the Aboriginals of Australia.
In practice it is found that U.-V.therapy usually immunizes patients to such conditions.

Demobilization of pigment is effected by hydrolytic enzymes which transform melanin into a fluid,colourless mass,this entering into the metabolism which takes place between the basal layer and the capillaries.

Pigment is thus a protector of the deeper layers of the skin,a heat-regulator,and a store-house for hormones.

Effects on Cholesterol & its Derivatives.---Vitamin-formation.

One is of opinion that a vitamin is a composite element,divisible into various parts,each of which has a specific function.

Vitamin D Formation.

The influence of U.-V.rays on the unsaponified fraction of the fatty matter in the skin leads to its elaboration of Vitamin D.
It has been shown that cholesterol ($C_{27}H_{46}O$),which is a monohydric sterol with one double bond,is present in the skin to the extent of about 14%,and contains the elements necessary for this process.
In its ordinary state,cholesterol has no anti-rachitic properties, but,if irradiated,it develops these very markedly.

Spectroscopically,cholesterol shows three maximum absorption bands--at 2,700 Å.,2,815 Å.,and 2,935 Å.
Ergosterol ($C_{27}H_{42}O$),which is contained in the most insoluble portions of cholesterol,shows similar absorption bands,but with greater intensity,thus proving that it is one of the factors concerned in the production of the cholesterol spectrum;that is to say,it is a pro-vitaminic substance:like cholesterol,it is a mono-hydric sterol,but it shows three double bonds.
Besides ergosterol,there are other derivatives of cholesterol which show absorption bands in the same regions;they also have double linkages,and are similarly pro-vitaminic.

When cholesterol or one of its derivatives showing double linkages is irradiated,the spectral appearances are completely altered,the three bands being replaced by one at 2,470 Å.This is the absorption band of Vitamin D.,the potent anti-rachitic factor.

Since cholesterol derivatives belonging to the same group as ergosterol differ slightly from each other in their unsaturated double linkages,one believes that their absorption bands will also differ:further,since these pro-vitaminic substances are similar but not identical,their activation will result in not one but several Vitamins D.,each one differing slightly in function.
It follows that activation of the cholesterol in the skin will mean the synthesis of as many "Vitasterols" as there are cholesterol derivatives present.That is to say,Vitamin D is a composite element,divisible into Di,Dii,Diii,and so on,each element having its own function in the regulation of general and mineral metabolism:thus,Vitamin Di may be associated with calcium,Dii with phosphorus,Diii with iodine,etc.;or,Di-phos.,Dii-ca.,Diii-I.,etc.

Unactivated ergosterol exhibits fluorescence,this property being lost after irradiation.It is not the ergosterol itself that is fluorescent,but the sensitizing element or elements contained in it.
A specific group of radiations activates the sensitizer,with resultant stereo-isomeric change;activator and activated are now in harmony,fluorescence ceasing during this phase of inactive relationship.The ergosterol is now sensitized to activation by wave-lengths 2,700 Å.,2,815 Å.,and 2,935 Å.,SYNTHESIS of a vitamin D element resulting.

Reductive processes affecting the vitamin will immediately restore the atoms to their original position in the molecule of the sensitizer, fluorescence being regained, and synthesis induced once more.

Ergosterol is not an isomer of the vitamin; it is the second last stage in a synthesizing process, the final product being the vitamin.
Vitamin D resulting from irradiation of ergosterol has an amorphous, glassy appearance, and absorbs wave-lengths at 2,470 Å.: one believes that these are vitamin-stabilizing radiations.
Since it has reached the acme of its energy-content, the vitamin cannot absorb wave-lengths longer than those that it has stored up within itself: the only wave-lengths capable of influencing the vitamin are those at and below 2,470 Å., the shorter wave-lengths affecting it in a disintegrative way.
Synthesis and reduction occur simultaneously under irradiation, maximum potency being attained when 73% of the ergosterol is still unchanged.

In a standard text-book on U.-V. therapy it says:[1] "In all photodynamic reactions a union occurs between the cell and the sensitizer". Again: "Ergosterol ($C_{27}H_{420}$), it may be concluded, represents the provitamin and is an isomer of irradiated ergosterol, which is the vitamin".

When union occurs between two substances, the end-result is a substance or substances more complex than either of those going to form it; in other words, whether the reaction is synthetic or reductive, the end-results are greater than either of the uniting elements.

The change produced in ergosterol by irradiation is obviously a physical one, since the crystalline gives place to an amorphous, glassy appearance.
In physical isomerism, the bodies are physically different, but they are chemically identical. If, as has been suggested, the changes were of isomeric type, the pro-vitamin and vitamin would be physical isomers showing similar chemical properties: the following facts disprove this:

ERGOSTEROL.

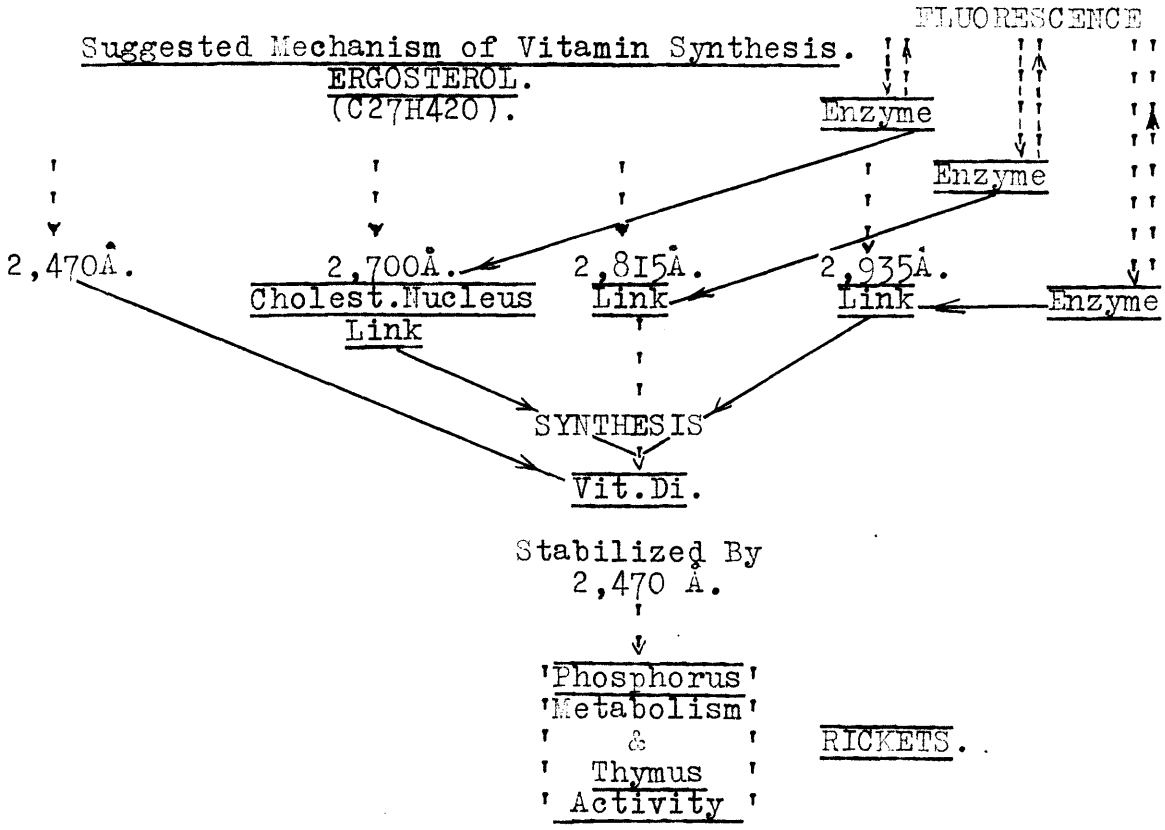
	Before Irradiation.	After Irradiation.
Solubility.		
95% Alcohol	0.2%	50%
Other Organic Solvents		Increased
Precipitation by Digitonin	+	-
Stability to Air and Light		Increased
Colour Reactions		
Aniline Hydrochloride	-	Red
Fuschine-H_2SO_4	-	Violet
Ammoniacal Ag. Oxide	-	Reduced
Starch Iodide	-	Pink $\xrightarrow{H_2O}$ Blue

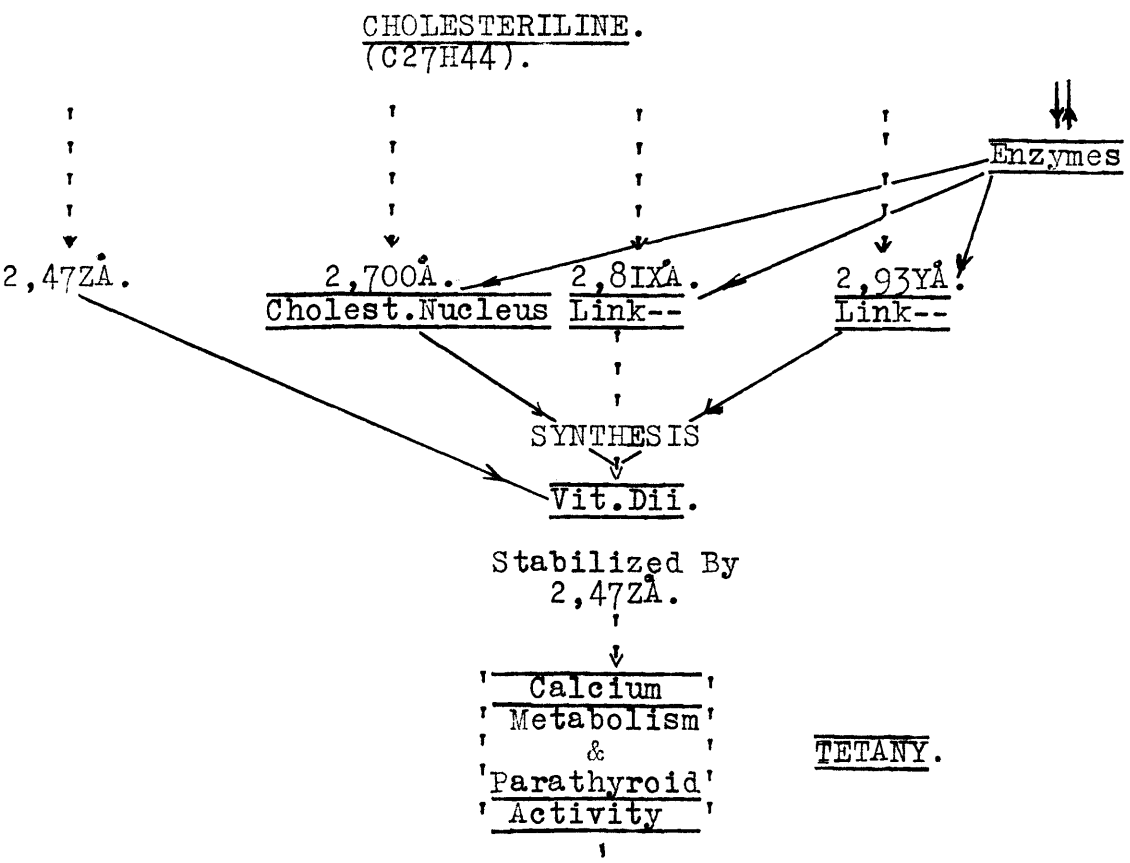
The colour reactions suggest the presence of aldehyde or ketone.[2]

Vitamin D formation is therefore neither disintegrative nor isomeric in nature; it is a synthetic process involving, in the skin, the activation firstly of anabolic enzymes and secondly of several complex elements, these blending to form a composite substance full of energy which is capable of release in one of several directions.
The rate of depletion of the bodily store of Vitamin D., when a supply of this factor is lacking, is affected by the ratio of calcium to phosphorus in the diet, which, under normal conditions, should be between I:I and 2:I.

The vitamin is thermostable in an almost neutral medium;in an acid medium,however,it undergoes gradual destruction,the rate depending on the reaction and the temperature.In an alkaline medium,even at elevated temperatures,it is stable.
It will be seen from this that acidotic conditions have an adverse effect on the vitamin.

Anti-rachitic potency of the vitamin is demonstrated in the cure of rats by the daily administration of I/I00,000 mg.of irradiated ergosterol.





And so on.

CHAPTER SIX.

General Biological Effects Of Radiations.

THE INORGANIC ELEMENTS OF THE BODY.

It is necessary at this stage to discuss the mineral constituents in order to facilitate description of their connection with the enzymes,hormones,and vitamins in relation to general metabolic processes.

The inorganic elements must be available in sufficient amount and in proper balance in respect to one another.
Salts of these dissolved in body fluids influence cell-membrane permeability,pH and osmotic equilibria,solubility of proteins, etc.,thus influencing muscle-contraction,irritability of the nervous system,secretion of digestive juices,perspiration and urine.
Phosphorus,sulphur,iron,and certain other inorganic elements are combined in the molecules of biologically important organic compounds such as glutathione,lecithin,haemoglobin,and certain other proteins.

CALCIUM.

Serum normally contains from 9-II mgm.per I00 cc.,children showing the higher values:this level is greatly reduced after parathyroidectomy,increasing considerably after injection of extracts of this gland.In infantile tetany values are low--3.5-7.0 mgm. per I00 cc.Minimum requirement for an adult is about 0.45 g.per day.

PHOSPHORUS.

This is the element that is primarily affected in rickets,the ratio of Ca.to phosphorus (approximately 2:I) being upset in favour of the former.A proper balance must exist between these two elements in order to insure normal calcification of bone. Minimum requirement for an adult is 0.88 g.per day.

SODIUM & CHLORINE--SODIUM CHLORIDE.

Serum should contain about 330 mgm.per I00 cc.;whole blood contains approximately 200 mgm.per I00 cc.,very little being present in the corpuscles.Deficient intake of this element results in subnormal growth-rate.
A certain relationship exists amongst Na.,Ca.,and K.,the first two being concerned in coagulation of the blood,while Ca.and K. maintain normal cardiac action,and influence irritability of nerves.
Sodium salts are of vital importance in the maintenance of the acid-base balance of the blood,while the chloride provides the HCl for gastric juice:the mechanism of the latter function may be a reaction between NaCl and acid phosphate.

POTASSIUM.

This is concentrated mainly in the corpuscles;the serum contains from I6-22mgm.per I00 cc.Whole blood values lie between I50 and 250 mgm.per I00 cc.,these being considerably reduced in anaemias. Deficiency in potassium results in growth retardation.
One thinks that certain cardiac arhythmias may be related to a disturbed K:Ca:Na ratio,thus explaining the mode of action of U.-V.radiations in the correction of such conditions.

MAGNESIUM.

The serum content is about 2-3 mgm.per I00 cc.,the whole blood content being about I.6 mgm.per I00 cc.
About 7I% of the body's supply is in the bones,while the muscle magnesium-content exceeds that of Ca.;in the blood plasma Ca. has the greater concentration.These two elements are mutually antagonistic;an excessive intake of one leads to increased output of the other.
One believes that magnesium is closely related to suprarenal medulla function.

SULPHUR.

The serum content of sulphates is about I.0-I.5 mgm.per I00 cc., the inorganic portion being present to the extent of 0.3-0.5 mgm. per I00 cc.;the whole blood content of the inorganic element is about twice that of the serum.
Sulphur exists in the glutathione molecule which is present in almost every cell;it is concerned with the growth of hair.

IRON.

The minimum requirement for an adult is I0-I2 mgm.per day.
Iron is concerned in oxidation reduction reactions in every cell of the body,transporting oxygen.It is intimately associated with calcium and copper,the three elements being mutually synergistic.

IODINE.

Present to the extent of 8-I5 γ per I00 cc.,iodine is essential for normal metabolic rate;the tuber cinereum,above the pituitary, contains a considerable amount of iodine:this may have some relation to the action of the pituitary on metabolism.

MANGANESE.

This is present in traces;an excess leads to toxic changes in the plant,calcium being able to protect it from such action.
Manganese,which occurs in the serum but not in the cells,is essential for normal reproductive processes,its absence resulting in atrophy of the testes in the male,and loss of maternal instinct in the female.It is believed to stimulate oxidate processes.
The relationship of manganese with sex-hormones will be shown later.

ZINC.

This is an essential element,and is present mainly in the cells.
The blood contains from I.5-2.5 mgm.per I00 cc.Zinc is essential for normal reproduction in rats.

ARSENIC.

Minute traces are found in the blood--about 63.8 γ per I00 cc.
During menstruation it increases by 50%,while in pregnancy it may reach 220 γ at about the sixth month.

COPPER.

Usually about 80-90 γ per I00 cc.It is mainly combined with the proteins in blood plasma,and is essential in the formation of haemoglobin;in certain types of anaemia the copper-content is increased.Since copper-porphyrin compounds are present in cells,it would appear that copper is concerned,along with iron,in processes of intra-cellular oxidation.

BORON.

In the absence of this element,the plant is unable to assimilate calcium:it is present in the body in minute traces.

SILICON.

In the form of SiO_2,silicon influences phosphorus assimilation;it is present in minute amounts.In the plant the amount of phosphoric acid taken up is proportional to the amount of water-soluble silicate in the soil.

RUBIDIUM.

The ratio Rubidium:Potassium is higher in the growing part of wheat than in the straw.There is a slight rise in the infant's liver content during the nursing period,suggesting connection with growth.

FLUORINE.

Excess of this element prevents proper calcium assimilation in the teeth,with the development of caries:I.5 parts per million in water is the safety limit.

SILVER.

The thyroid and tonsil contain a considerable amount of this metal.

TIN.

This is found in the brain,spleen,thyroid,and mucous membrane of the tongue.

BROMINE.

Present in the amounts of 0.8 - I mgm.per I00 cc.of blood,this element seems to have an intimate connection with the mentality of the organism.In maniac-depressive psychoses,bromine is reduced in amount during attacks,returning to normal with clinical improvement in the condition.This will explain the function of bromides in the treatment of such diseases,while,one thinks,it also explains the beneficial effects of U.-V.therapy in various depressive conditions:irradiation will have a regulatory effect on bromine and allied minerals,the level of these being raised. The pituitary,particularly the anterior lobe,contains the greatest amount of this element,the concentration being seven times that in any other organ. Bromine decreases in amount after 45, while at 75 it is usually entirely absent.

A short account of enzymes or sensitizers will precede descriptions of hormones and trephones:the synthesis and functional activity of these latter elements are entirely dependent on the presence of enzymes.

ENZYMES.

These are closely associated with the proteins with which they have much in common:they are colloidal,non-diffusible,and are mostly hydrolytic.We have proteolytic (proteolase),lipolytic (lipase),amyolytic (amylase),and other types.
Some enzymes are more active in acid solutions,while others require alkalinity of fluids:one thinks that this will explain many of the aberrations due to acidotic and alkalotic states.

Such enzymes are capable of reversible hydrolysis,a state of equilibrium being maintained in tissues by this action...hydro-synthesis.

Enzymes undergo stereo-isomerism,increasing the velocity of chemical reactions without being permanently changed themselves.
Activators.

Certain of the more important enzymes do not occur performed within the cells,but are present in the form of a mother substance which must be transformed in a specific manner by a specific element:this transformation of the inactive zymogen into the active enzyme is called activation.
Enzymes are specific as to the character of the substances on which they act,being capable of influencing only those elements which have a stereo-isomeric relationship to themselves.
One believes that the vitamins are the zymogen transformers and enzyme activators,liberation of vitaminic energy inducing stereo-isomeric changes in the enzymes,such changes in turn sensitizing the substrate to either synthetic or reductive wave-lengths of energy.

Most of the energy of living matter is derived from oxidative processes,the essential feature of all such processes being the transfer of negative electrons from the substance oxidized to the substance reduced,whereby the number of negative valencies of the former is reduced,or positive valencies increased.
Biological oxidations involve this transfer of electrons.

HORMONES.

Hormones act (a).directly on cell metabolism itself,and (b).on the specially receptive myoneural junctions of the vegetative nervous system.
This action on the cells may be general (Thyroid),or specific (Pituitary),most hormones belonging to the latter type.
The intra-cellular effects of hormones depend on the permeability of the cell-membranes to them,specific cell "receptors" being necessary to allow of their penetration of the cells of their selection.One is of opinion that the minerals are the "receptors", a certain mineral or group of minerals being responsible for the maintenance of pH and osmotic balance suitable to the specific hormone.
Chemical reactions within the cells are specific to the hormone, and depend on the nature of the radical;there is thus actual participation of the hormone in cell metabolism;one does not regard these elements as sensitizers or catalysts.

Participation in the metabolism of nerve-endings in the vegetative nervous system influences the tonicity or irritability of this system,thereby affecting the intimately connected central nervous system.

The vegetative nervous system is made up of motor efferent nerves which supply involuntary organs almost wholly independent of conciousness.The sympathetic portion.-From the sympathetic ganglia fibres pass via the spinal nerves and blood-vessels for distribution to skin,blood-vessels,glands,and abdominal and pelvic viscera.
The chromaffin tissue in the medulla supra-renalis is the largest single unit,its internal secretion stimulating sympathetic activity,whether this means increased or decreased function.

The para-sympathetic portion.-This is concerned in the conservation of resources in the body,building up reserves to be used in the time of need by the sympathetic:a physiological antagonism exists between the two.

The thyroid,posterior pituitary,supra-renal medulla,and gonads appear to be involved in sympathetic stimulation,while the parathyroids,anterior pituitary,cortex supra-renalis,thymus,pineal, and insular part of the pancreas affect the para-sympathetic.
The former group accelerates metabolism--catabolic dissimilatory, while the latter retard--anabolic assimilatory.

TREPHONES.

These elements,which one believes to be elaborated in the endocrine glands,are nutrient substances which are used up in the building of protoplasm;they contain nitrogenous linkages.
Carried by the leucocytes,trephones are of embryonic growth-promoting type,being used in the repair of tissue,and in normal cell activity.It is one's opinion that such nutrient elements are incorporated in the phospholipins,aminolipins,etc.,elaborated in certain of the endocrine glands;they accompany the hormones in the leucocytes,and participate in their intra-cellular chemical reactions.
The trephones are derived primarily from amino acids,and secondarily from combinations of these with lipoid elements.

INTER-RELATIONSHIP OF ENDOCRINE GLANDS.

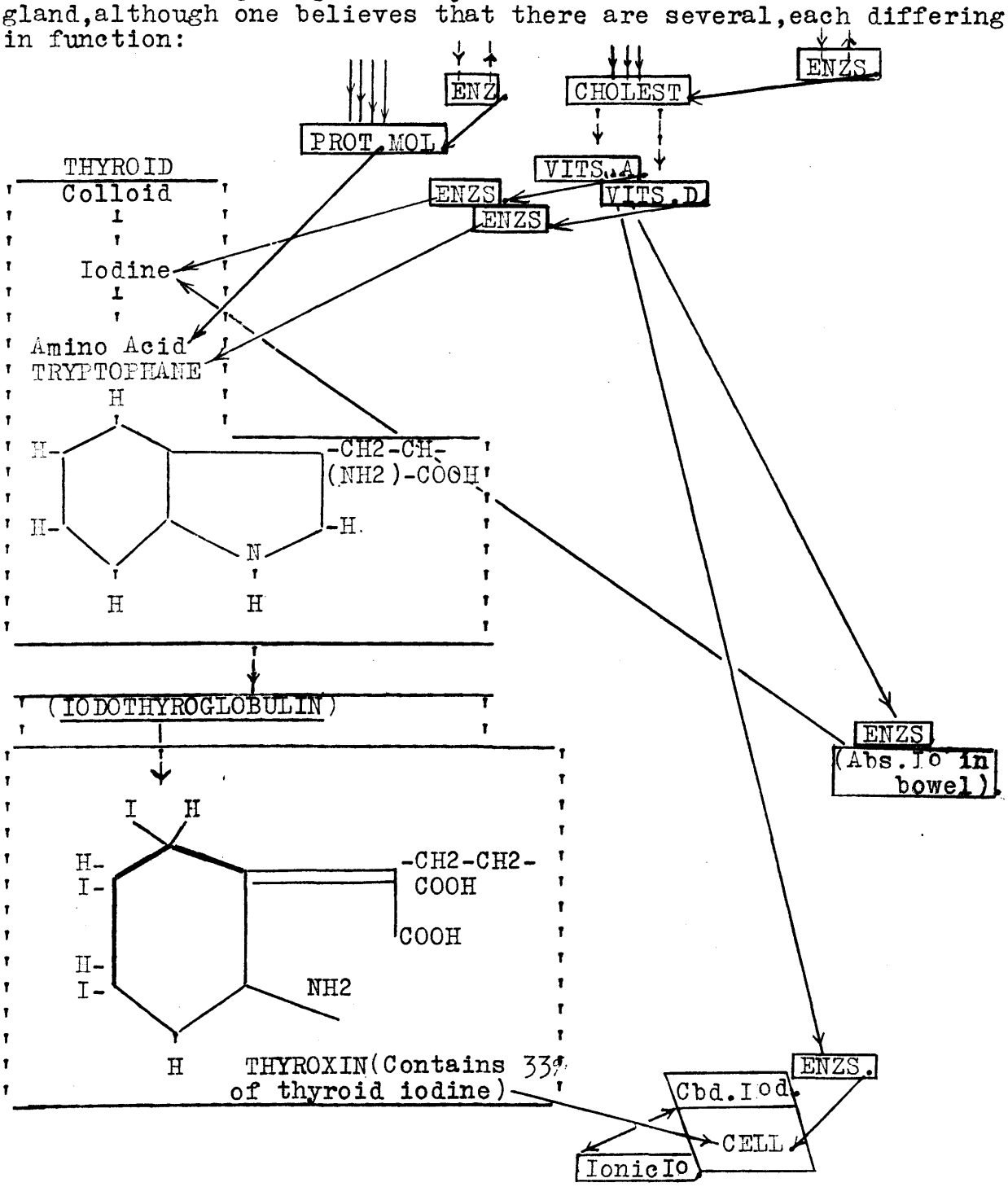
One believes that the antagonism and synergism existing between glands or groups of glands will be expressed in the relationship of their specific minerals one to the other:for example,the mutual antagonism of calcium and magnesium will express mutual antagonism between parath. and supra-renals.

HORMONE SYNTHESIS FROM ABSORBED AMINO ACIDS.

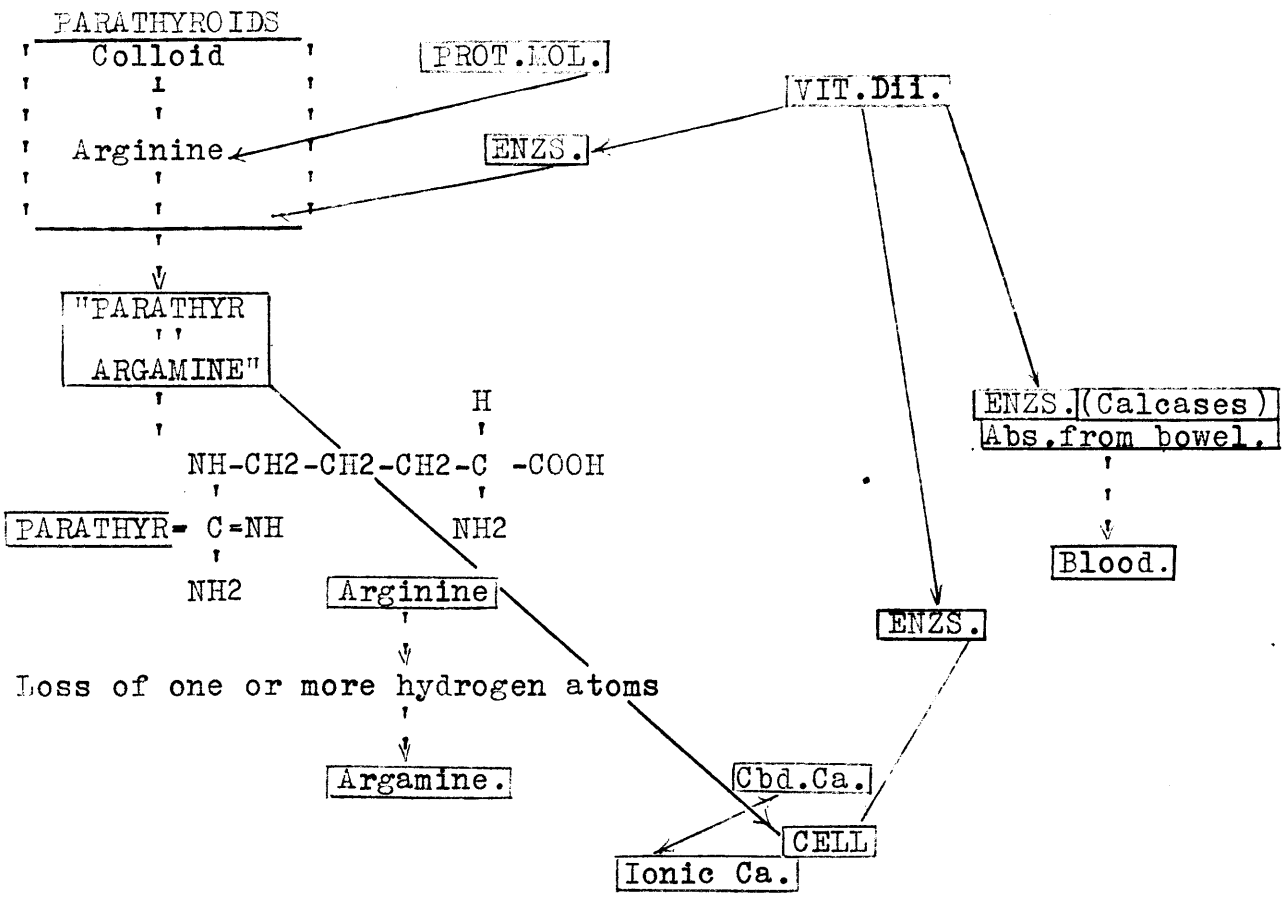
One is of opinion that the amino acids liberated from the protein molecule are the pro-hormones, being taken up from the blood by the endocrine glands and elaborated into various hormonic elements. Each gland has several hormones--one for every specific activity; its nature will depend on the chemical structure of the amino acid from which it is derived.

Since the glands vary in structure, the nature of the hormone elaborated in any one gland will be specifically dependent on its chemical reaction with the amino acid radical; in other words, the specific function of an endocrine gland is determined by the chemical nature of its substance which is linked to the amino acid radical: the pro-hormones taken up by the different glands are of similar type, the end-products of synthesis in each case differing, fundamentally, only in this linkage to the radical.

In the following diagrams only one hormone will be traced in each gland, although one believes that there are several, each differing in function:

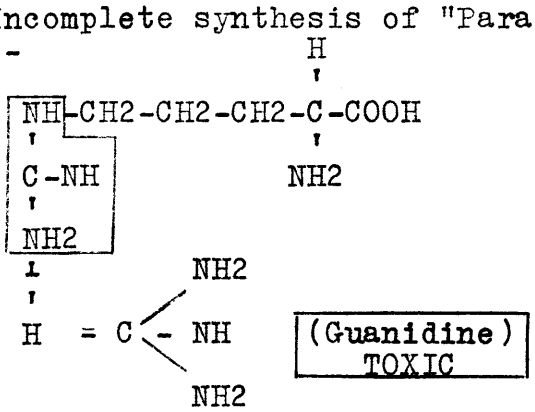


The effects of Ultra-Violet rays in hypo-and hyper-thyroidic states will be discussed later.



Vitamin Dii Deficiency.

--------Incomplete synthesis of "Parathyrargamine" in the Parathyroids:-



TETANY.

Calcium,which exerts a sedative effect on the nervous system,does so,one believes,by facilitating the diffusion of "Parathyrargamine" through the cell walls,the hormone exerting its effects by virtue of its contained valeric/valerianic acid group.Deficiency of Ca. means decreased permeability of the cell walls to the hormone, with consequent increase in excitability of the nervous system. In tetany,various aberrations occur,each tending to aggravate the other:

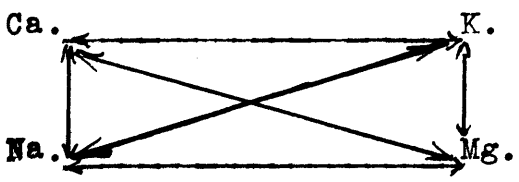
There is liberation of guanidine which links up with other elements,forming methyl guanidine and other such toxic products: these excite the nerves to the point of over-stimulation. The injection of methyl guanidine produces tetanoid effects. The valeric acid group is rendered inactive as a nerve sedative through its combination with other substances.Thus,we have increased toxic,and decreased sedative,effects.

Since the normal parathormone influence on the cell metabolism is absent,the combined calcium of the cell will become abnormal,thus upsetting the ratio existing between it and the ionic calcium in the blood:osmotic pressure,pH,permeability of cell-membrane,inter-relationship of minerals,etc.are affected adversely, calcium-fixation becoming extremely difficult,or impossible. Such changes reduce calcium to a low level in the tissues.

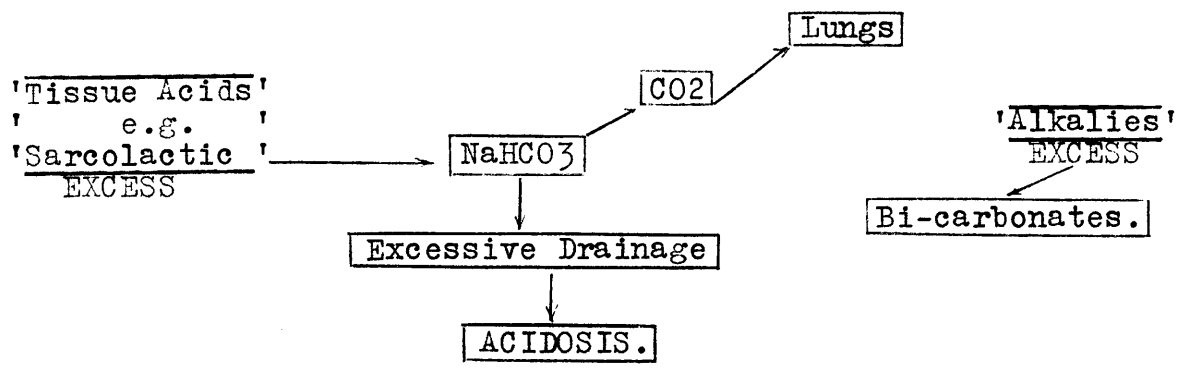
Since calcium and magnesium are mutually antagonistic,decrease in the former will give a free hand to the latter:injection of magnesium in rats causes convulsions.
One is of opinion that magnesium is the mineral specifically devoted to the supra-renal medulla hormone--epinephrine:excessive action of this mineral will mean increased permeability of cell-membranes to epinephrine,the result being hyper-excitation of the vegative nervous system.The antagonism existing between adrenal medulla and parathyroids will thus be expressed in a mineral sense.

Increased excitability of muscles (through over-stimulation of controlling nerves) will mean increase in sarcolactic acid,with consequent drainage of alkaline reserve:
Ca.and K.are nerve sedatives,and mutually synergistic:Na.and Mg. are nerve excitants,and mutually synergistic:their inter-relationship can be shown as follows:

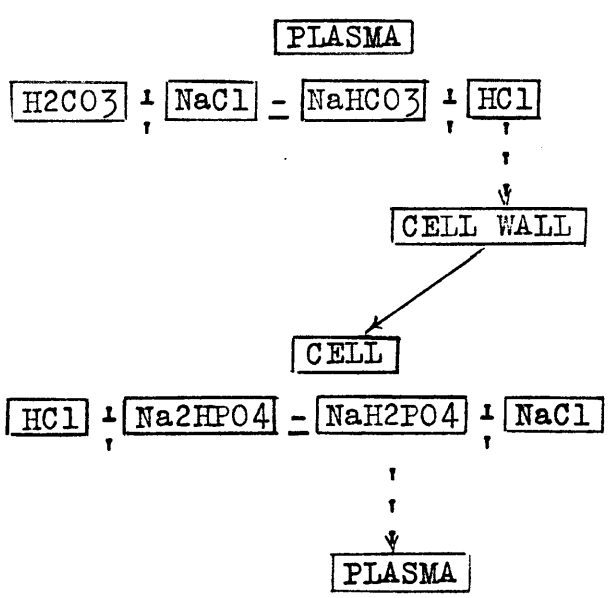
⟷ = Mutually synergistic: ⟷ = Mutually antagonistic.



$NaHCO_3$ plays a great part in the maintenance of balance between H and OH ions in the blood;it constitutes the "Alkaline Reserve".



Dissociated HCl of NaCl of plasma can,when pH increases,pass into the cells and take up some of the sodium of the Na_2PO_4,turning it out as NaH_2PO_4;this is excreted by the kidneys,thus ridding the blood of excess H ions:



An excess of this action will explain,in part,the mechanism involved in phosphate-reduction seen in rickets:this condition and tetany often co-exist,the clinical picture depending on whether emphasis is on Calcium or Phosphorus deficiency.Usually,the Ca. level is normal or slightly subnormal in rickets;one would think that in the latter case there will be an under-current of tetany present.

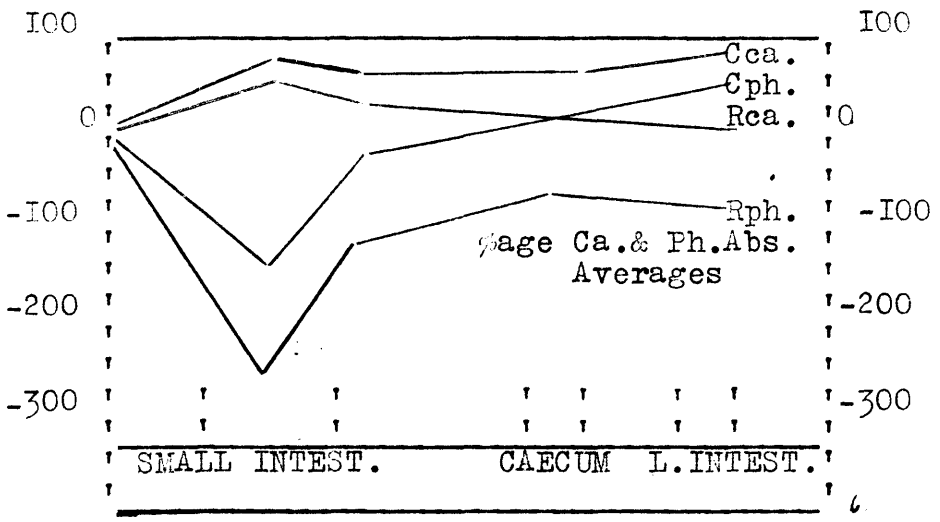
Tetany exhibits undue excitability of the nervous system,this being demonstrable in heightened excitability of motor,sensible, sensory,and vegetative nerves,and,under certain circumstances,in paraesthesias,and,for the most part,painful spasms,with intact conciousness:or,it becomes manifest through phenomena of irritation on the part of vegetative nerves.There are also trophic and metabolic disturbances;these latter are due to deficiency in hormones, and,one believes,their accompanying trephones.

Protein metabolism is increased to an abnormal extent;there is increase in urinary N2--due to increased %age of ammonia and peptide N2.There is also accumulation of toxic products of protein metabolism,chiefly guanidine.

The biological picture in tetany represents a "Vicious Circle": deficiency in Vitamin D element not only means defective hormone synthesis,but also inefficient activation of the "Calcase" in the gastro-intestinal tract,with resultant deficiency in calcium absorption:we thus have starvation in the main departments,with consequent chaos in the mineral and general metabolism,and concomitant endocrine unbalance.

It is well-known that calcium is vitally necessary in blood coagulation;deficiency in this element results in an increase in the time necessary for clotting:this clotting-time is rapidly restored to normal under U.V.treatment.

The following diagram illustrates the action of Vitamin D on the intestinal enzymes calcase and hexosephosphatase:



R-Rachitic Diet:C-Cod Liver Oil.

Cod liver oil is of great value in tetany,rickets,etc.,by virtue of its contained Vitamin D.The relative values of U.-V.and cod liver oil in these and other conditions will be discussed later: the balance is most decidedly in favour of Ultra-Violet rays.

THYMUS.

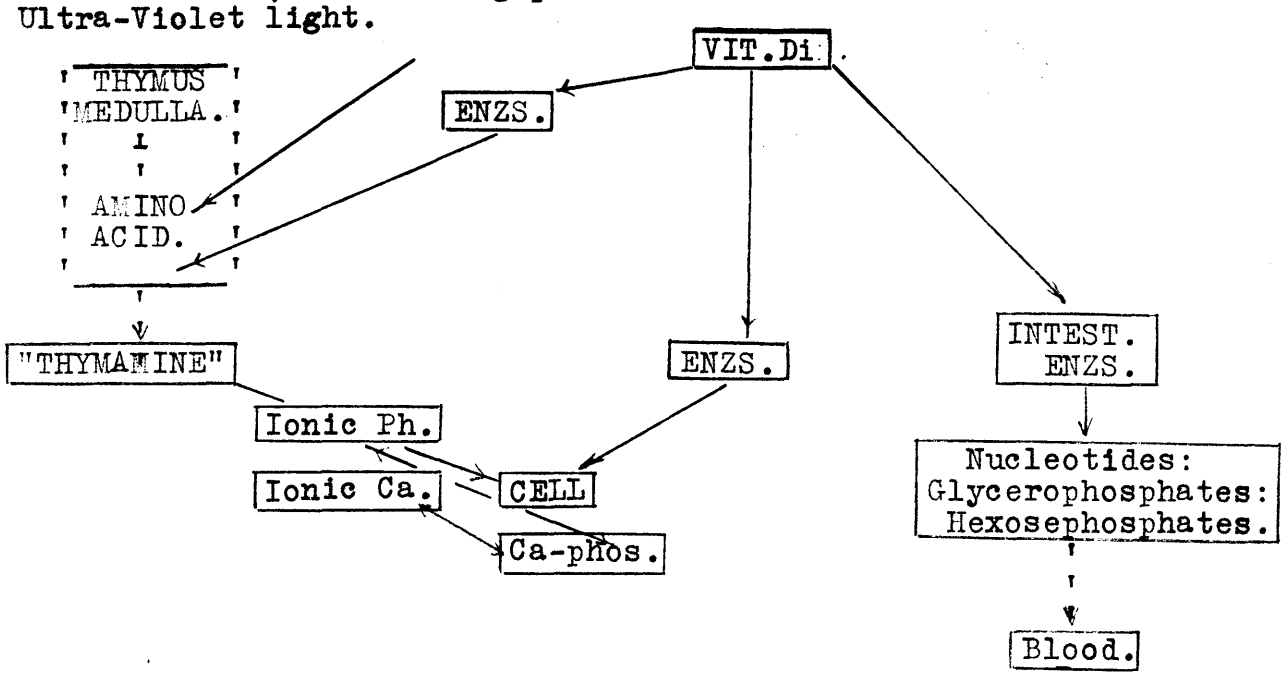
The thymus appears to excercise three outstanding functions, viz.,the power of fixing phosphoric acid,an inhibitory effect on the development of secondary sex characteristics,and a stimulative action on lymphoid tissue (increasing lymphocyte-output and therefore showing its intimate connection with anti-toxic effects)

One is of opinion that a mutual synergism exists between thymus and parathyroids,this being expressed by the relationship of their specific minerals-phosphorus and calcium.
Thymus and parathyroids are intimately connected with the ossification of bones,the ratio of calcium phosphate to ionic calcium and ionic phosphorus determining the normality or abnormality of bone structure.
Deficiency in Vitamin Di will lead to sub-normal hormone synthesis in the thymus,and to inefficient activation of intestinal and cellular hexosephosphatase.

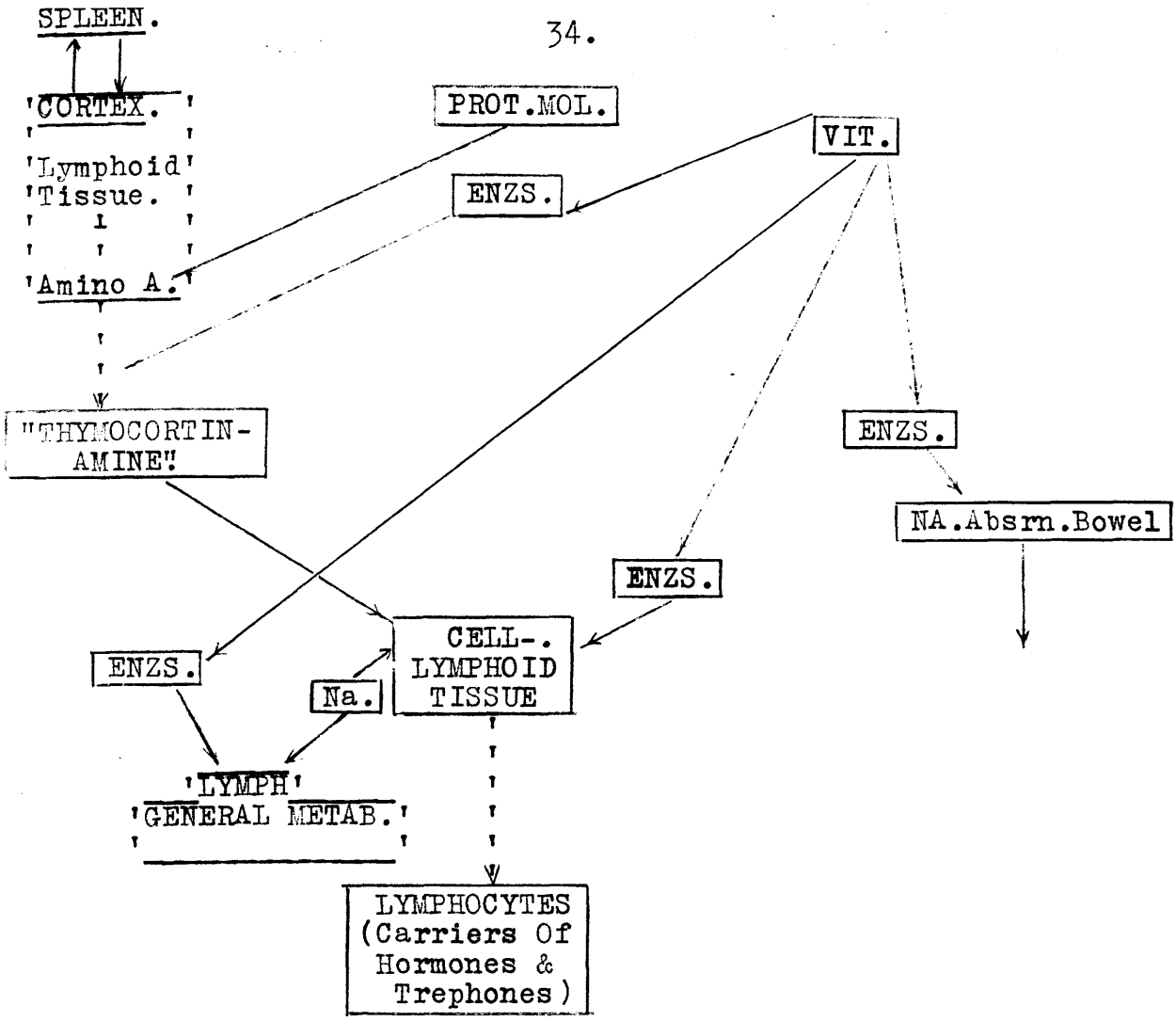
This enzyme,under normal conditions,induces precipitation of ca. phosphate from soluble calcium salts of phosphoric esters such as are present in the blood:such reactions are incomplete in Vitamin deficiency,the severity of the condition being commensurate with hypo-vitaminosis.
The plasma content of the enzyme is considerably increased,this being an attempt at compensation by the enzyme diffusing from the osseous tissue to the blood.

The inorganic phosphorus-content of the blood is usually reduced to about half the normal amount of 4-5 mgm.:although the bone ca. is greatly reduced,the serum content remains about normal.

In one's opinion,the prima facie evidence in favour of thymus involvement in the causation of rickets lies in the relation of this gland to growth-processes-particularly those affecting bone: rickets does not occur after puberty,-the time when such growth-processes mature.Decrease in thymus activity co-incides with the cessation of active growth.
Extirpation has produced rachitic symptoms in dogs.
There is a seasonal variation in blood phosphate values,these reaching their minimum in late winter and early spring,and maximum in mid-summer,thus running parallel to the seasonal variation in Ultra-Violet light.



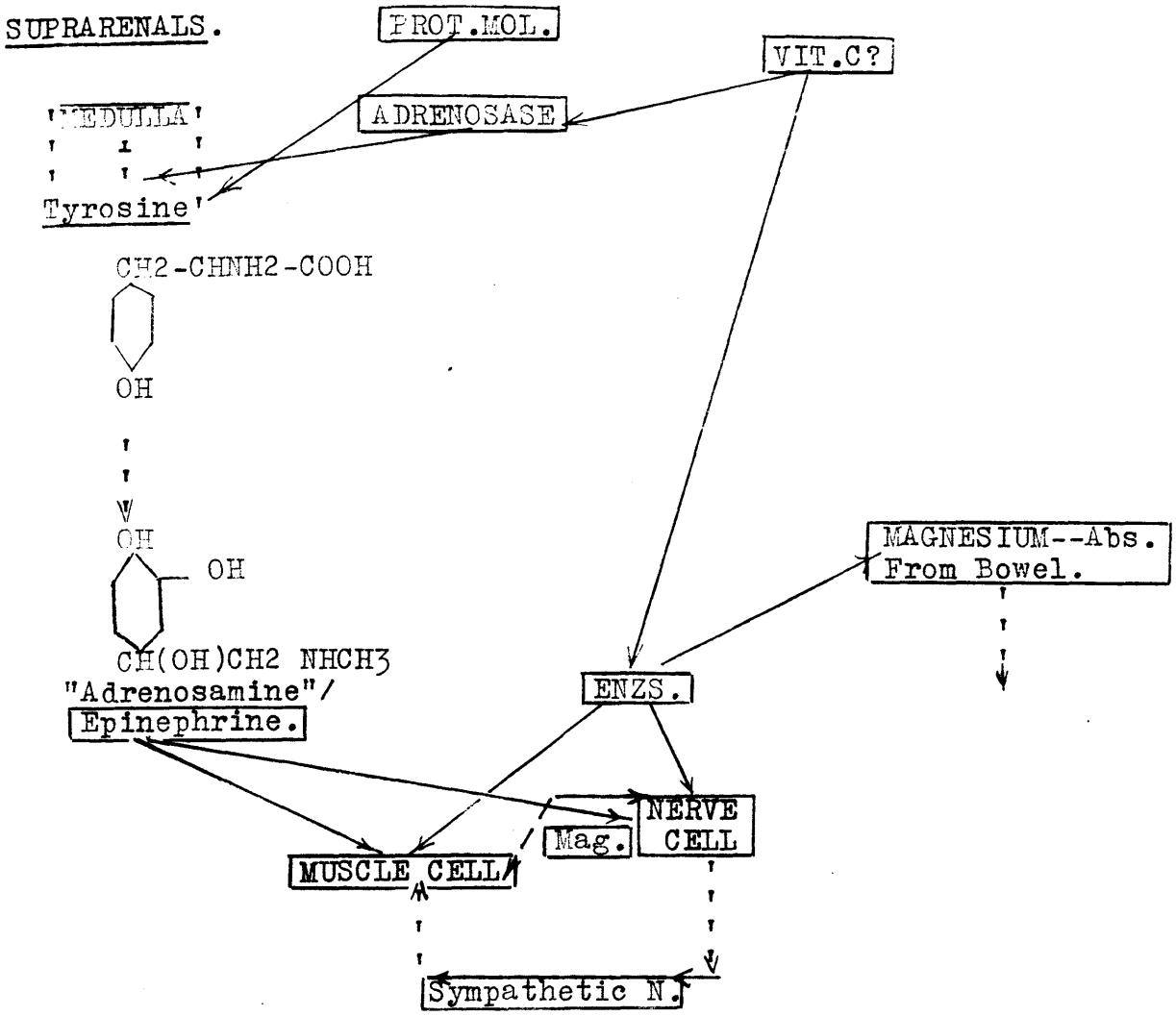
Since hexosephosphatase shows optimal activity in pHs of 8.4 and 9.4,its function may be interfered with in conditions which cause marked changes in hydrogen-ion concentration:this may be a causative factor in the development of an undercurrent of rickets in tetany.The presence of marked alkalinity in the bowel may adversely affect the function of the enzyme,leading to decreased absorption of inorganic phosphorus.



One is of opinion that the thymus cortex is predominant in lymphocytic activity, stimulating the output of these cells, and regulating their discharge of hormones (metabolic stimulant and antigenic factors) and trephones (nutrient elements) into the general cell metabolism.
Sodium is the main mineral in lymphoid tissue and lymph: one thinks that it is concerned intimately with permeability of the lymphocyte walls, allowing of discharge of its contained elements into the cell metabolism, and recharge with toxic and waste products.
This function of thymus cortex is at its maximum during the period of active growth.

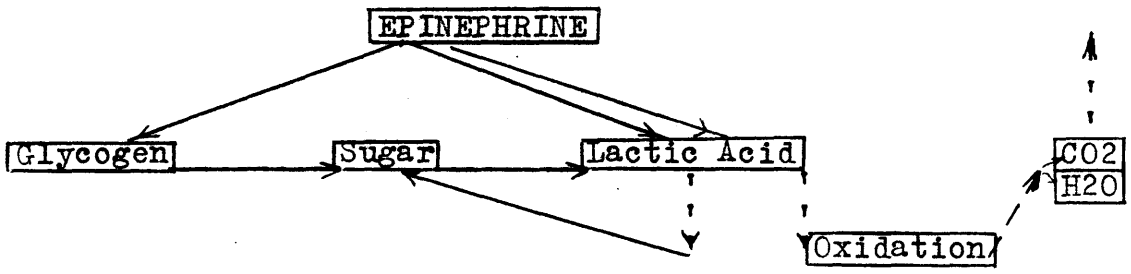
The above partly explains the mechanism involved in the production of lymphocytosis by Ultra-Violet radiations.

SUPRARENALS.



FUNCTION.

Increased muscular contraction results from increased blood supply (vaso-dilatation) and chemical action on muscle cell.
Metabolism of fatigue products:



HYPO-FUNCTION.

There is inefficient metabolism of fatigue products and of carbohydrates----------Asthenia.
The beneficial effects of U.-V.radiations in post-influenzal asthenia,for example,are due to their marked influence on the output of epinephrine,and on the elements regulating its action.

HYPER-FUNCTION.

The menopausal syndrome exemplifies predominance of suprarenal function:vaso-motor irritability produces flushings,palpitation, cerebral symptoms,etc.,these being accompanied by metabolic disturbances resulting in obesity,rheumatism,diabetes,etc.
This endocrine unbalance follows ovarian upset.
One has seen such cases improve markedly under U.-V.treatment.

SUPRARENAL REACTION TO U.-V.IRRADIATION.

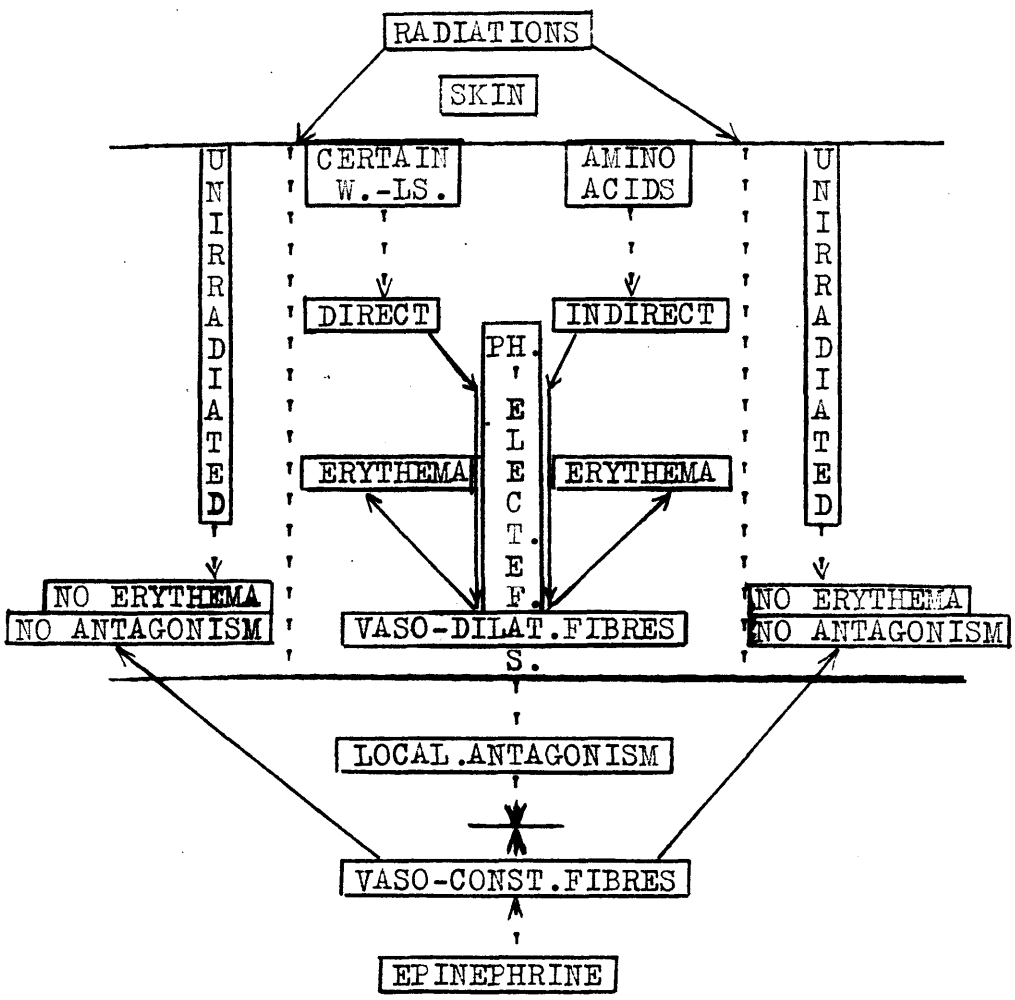
In a recent text-book on U.-V.therapy it is said that the principal effect of radiations on the endocrine system is depression of the suprarenals.
One does not believe that an actual depression occurs under normal circumstances;the following explains one's reasons for adopting this view:

Effects Of Depression Of Suprarenals.

Since erythema is the expression of vaso-dilatation in the irradiated area,one would expect to find this sign of vaso-dilatation in non-irradiated areas also,were the action of the rays generall suprarenal-depressive:it is well-known that erythema is confined to the irradiated area. A general depression would result in marked lowering of blood-pressure.

Such selective depression would also lead to unbalance in the endocrine system,excessive action of antagonists being allowed: this obviously does not occur.
Further,the condition would be one of hypo-adrenia,with its attendant muscle-fatigue symptoms.
In correct doses,U.-V.radiations have an invigorating effect.

Method Of Action...Local Antagonism To Epinephrine.



The question might arise: "How do you account for the decrease in blood-sugar in diabetes?".
One believes that only those cases in which the "Islets" are capable of some response to stimulation will show reduction of blood-sugar under U.-V.irradiation.
Improvement in hyperglycaemia results,not from suprarenal depression,but,from "forced feeding" of the pancreas with its specific pro-hormonic amino acid/s.The "Islets" participate in the general endocrine stimulation.

"How is improvement brought about in hypo-and hyper-piesis?"

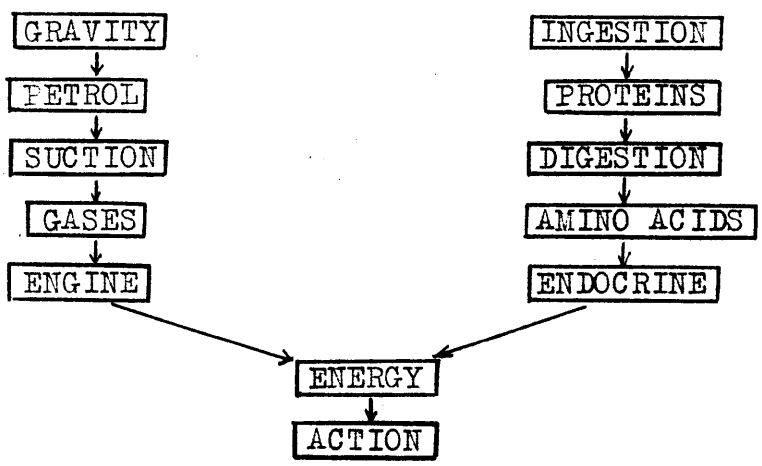
Hypopiesis.

A manifestation of hypo-adrenal function,this condition can be improved by the restoration of medullary hormone-synthesis to its normal standard by "forced feeding" of tyrosine and other amino acids.The general endocrine regulation will normalize anti-suprarenal hormones.Arterial tone will be restored.
The area irradiated should be limited to minimize local vaso-dilatatory effects;if this is done,suprarenal stimulation effects will outweigh those occurring locally.

Hyperpiesis.

The induction of a generalized erythema (antagonism to epinephrine action in the skin) will,in the first place,lower the pressure,reduction being maintained by the general regulation of the endocrine chain which follows absorption of the amino acids: hypo-function of adrenal antagonists will be corrected,their normal adrenal-curbing powers being restored.

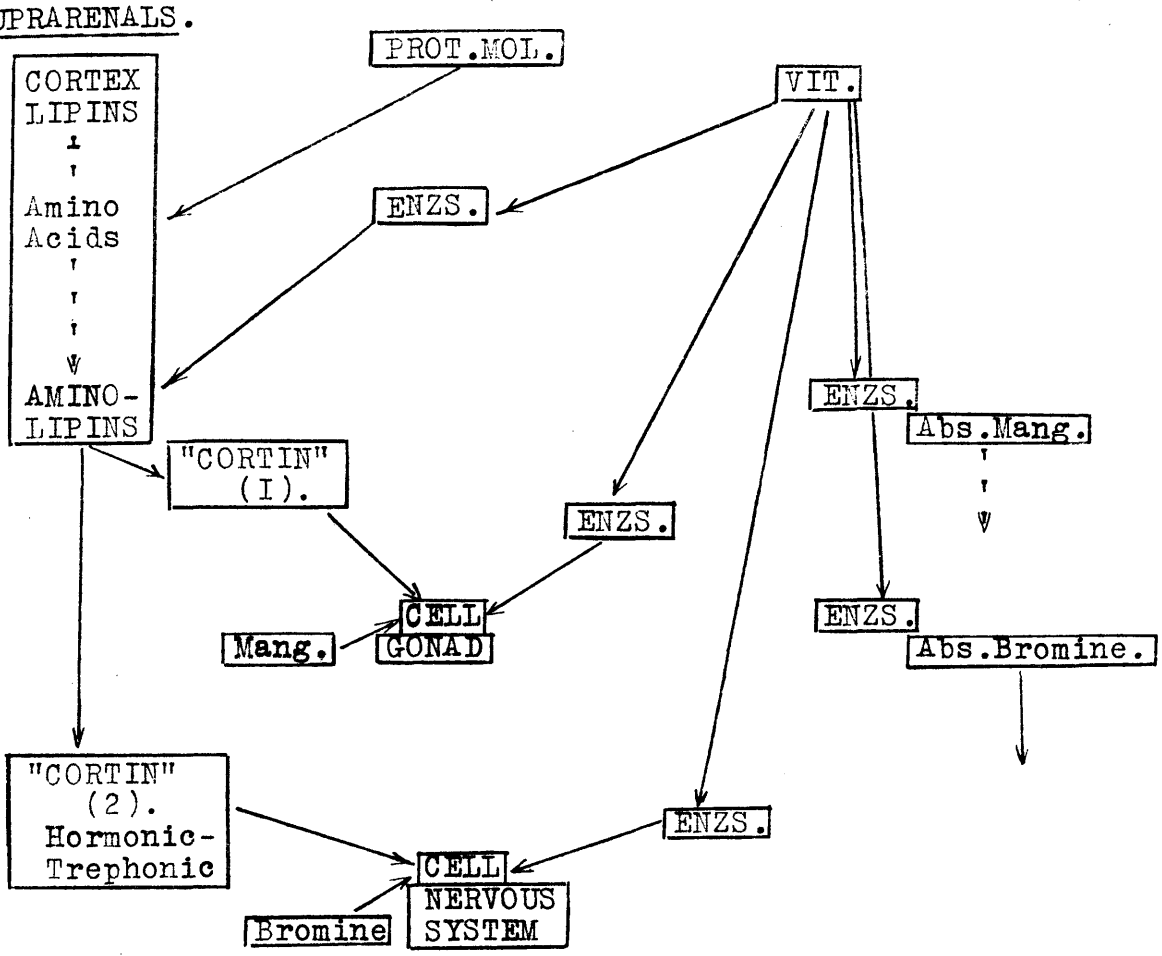
SIMILE...ACTION OF RAYS ON ENDOCRINE SYSTEM.



U.-V. radiations constitute the "Super-charger" of the endocrine gland,"force-feeding" its fuel (amino acids).This makes for greater energy-output and more efficient action.

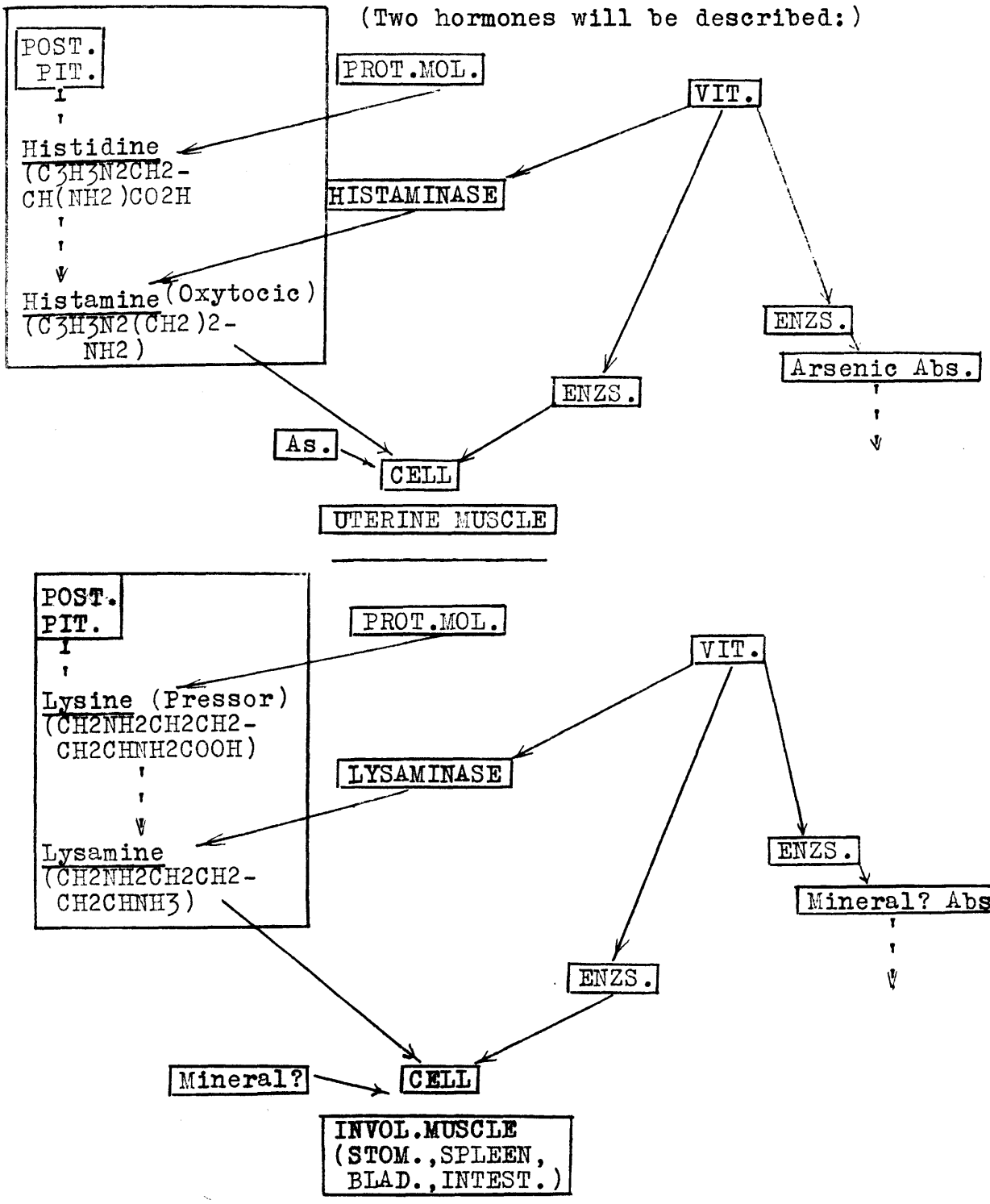
(Two hormones will be indicated).

SUPRARENALS.



The cortex,which is developed from the genital ridge,has a high content of lipoids--substances which appear to be intimately connected with the generative system.
Enlargement occurs during pregnancy,while a small cortex means deficient sexual development,and a large cortex sexual precocity.
Its connection with the central nervous system is seen in the marked hypertrophy occurring in the normal embryo,and in its absence in anencephalous monsters.

(Two hormones will be described:)



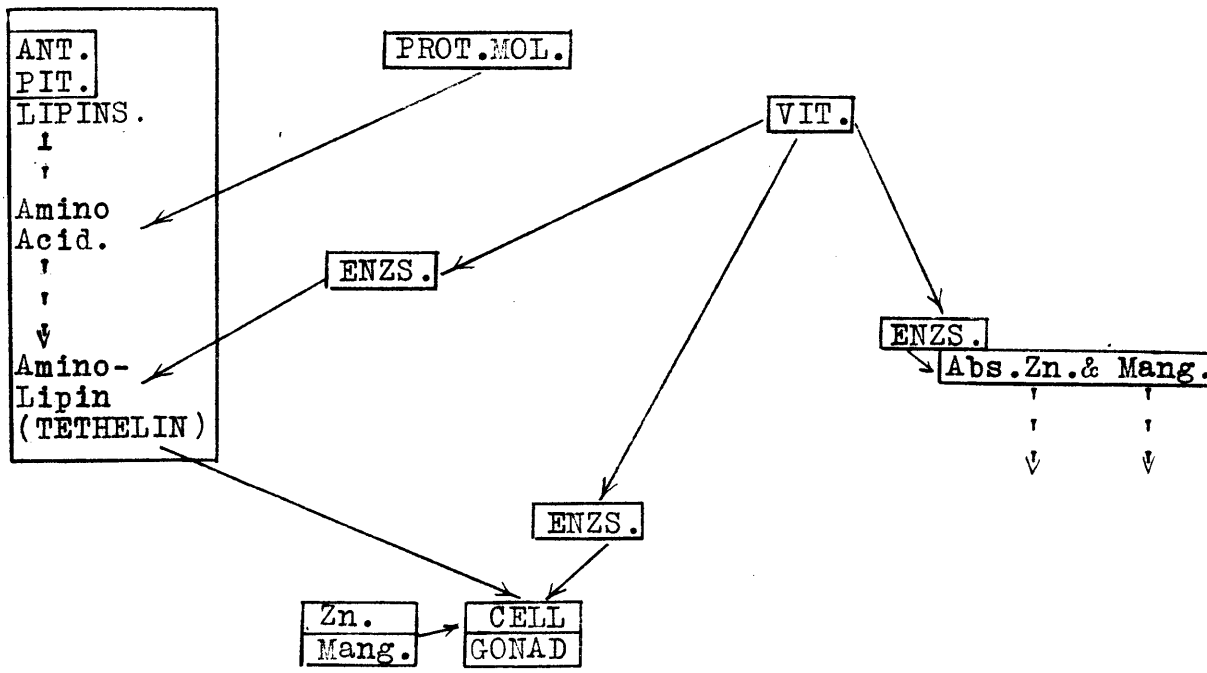
Kamm[8] regards the posterior lobe principles as being both basic and apparently amines.

The above hormones appear to act directly on the cell, in contradistinction to epinephrine which gives either contraction or relaxation depending on the character of the autonomic nerve filament supplying the plain muscle.

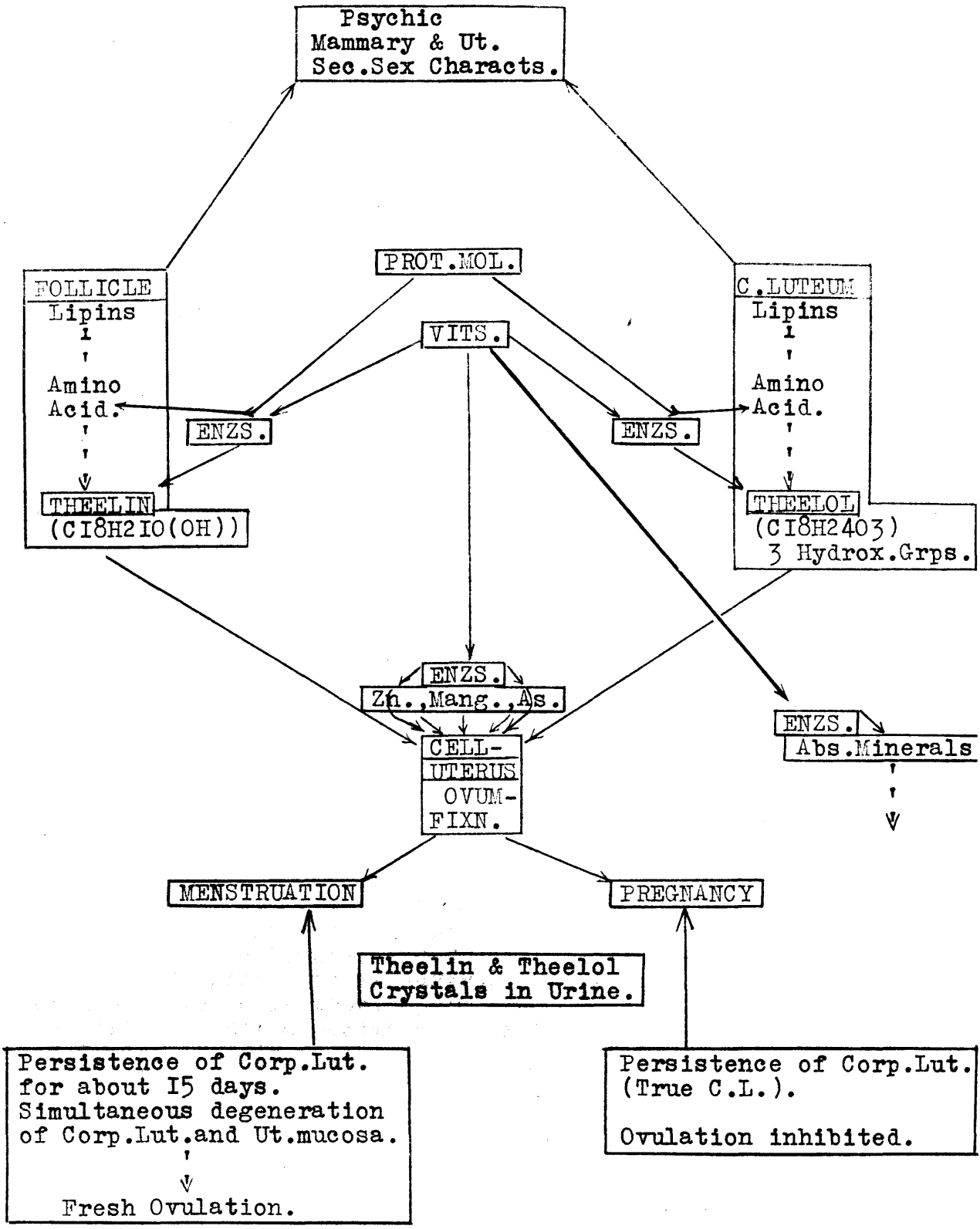
Galactagogue Effects.--Volume of milk is increased by contraction of the plain muscle round the alveoli. This could explain the increase in milk which one has seen under U.-V. treatment.

Cardio-vascular Effects.--Blood pressure is increased by the direct effect on vessel walls. Hypopiesis--This effect may partly explain the increase in pressure seen under U.-V. irradiation.

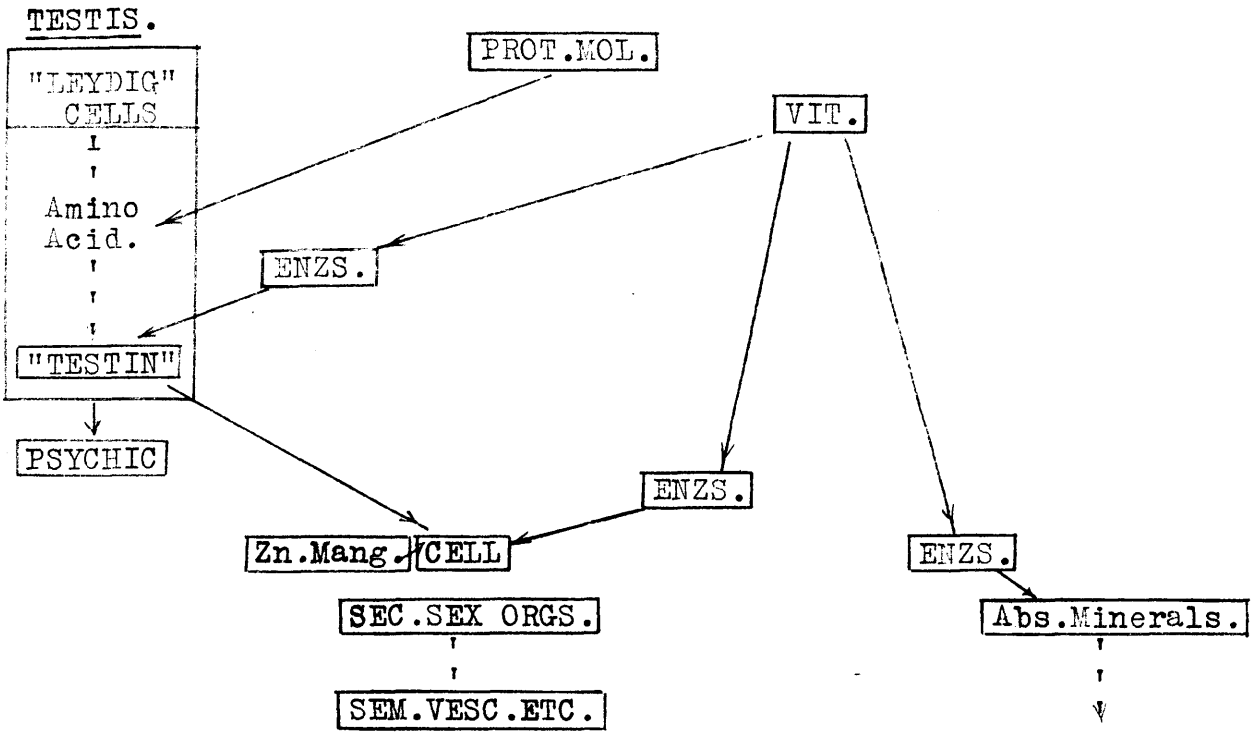
One has linked Arsenic with histamine because of the moderate increase in this mineral during menstruation,and the marked increase during pregnancy.Improved relations between these two elements may account,in part,for the rapid onset of delayed menstruation which one has seen after a single irradiation.



OVARY.

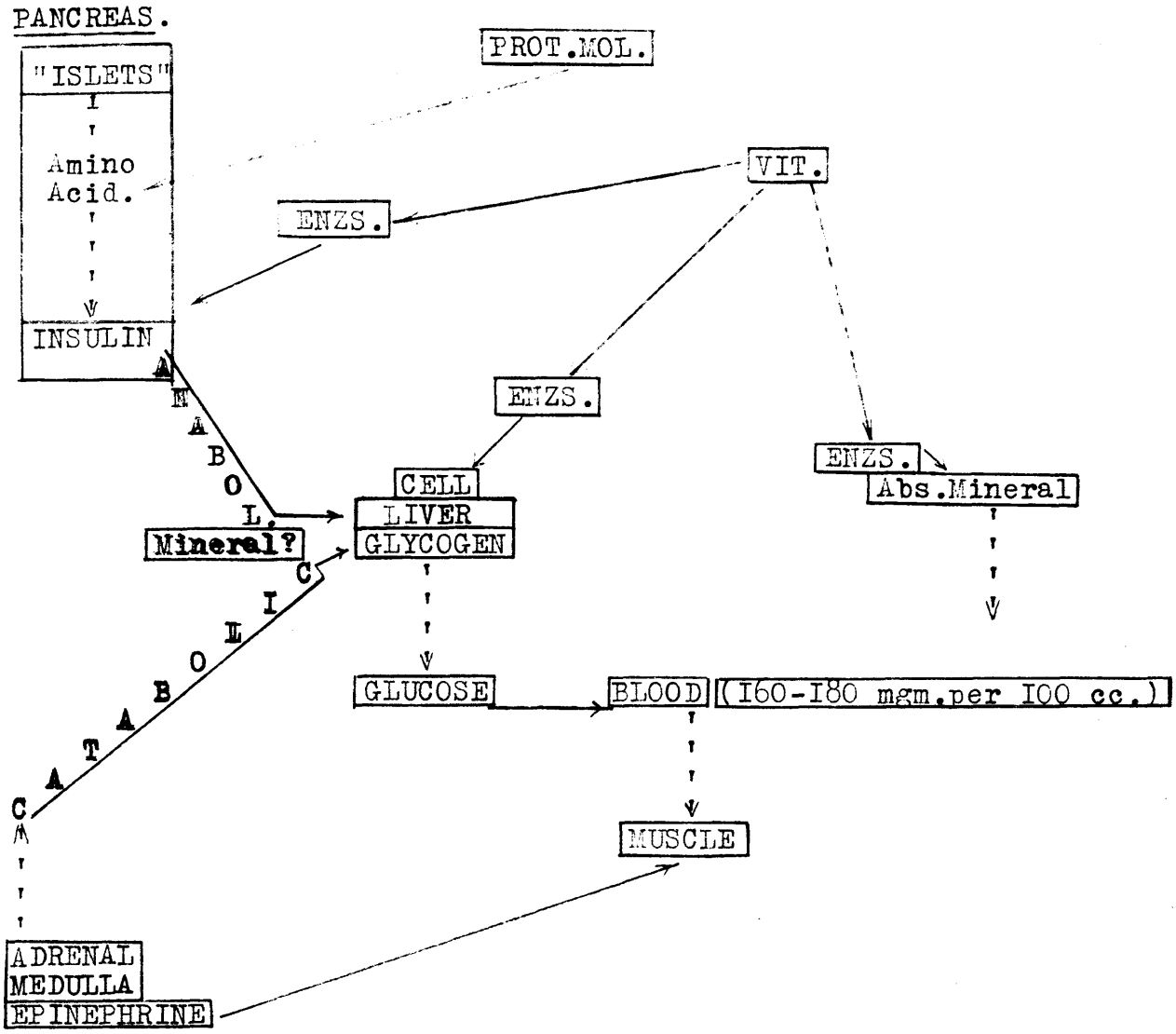


The above demonstrates part of the mechanism involved in the regulation of functional disturbances by U.-V.radiations.



One is of opinion that the trephonic elements intimately related to the generative system are specially rich in phospholipins;the presence of phosphorus in semen will be due to this.

Since the gonads are dependent on the other endocrine glands for their proper development and function,disturbance in any one of these glands will have an adverse effect on the generative system:the converse is true.
One believes that a condition akin to the climacteric period in the female is seen in the male,this condition varying in severity from an extremely mild psychic and physical upset of indefinite type to a very definite hormone unbalance with emphasis on the gonadal elements.Such cases have been benefited considerably by U.-V.therapy,the mechanism consisting of balance-restoration.



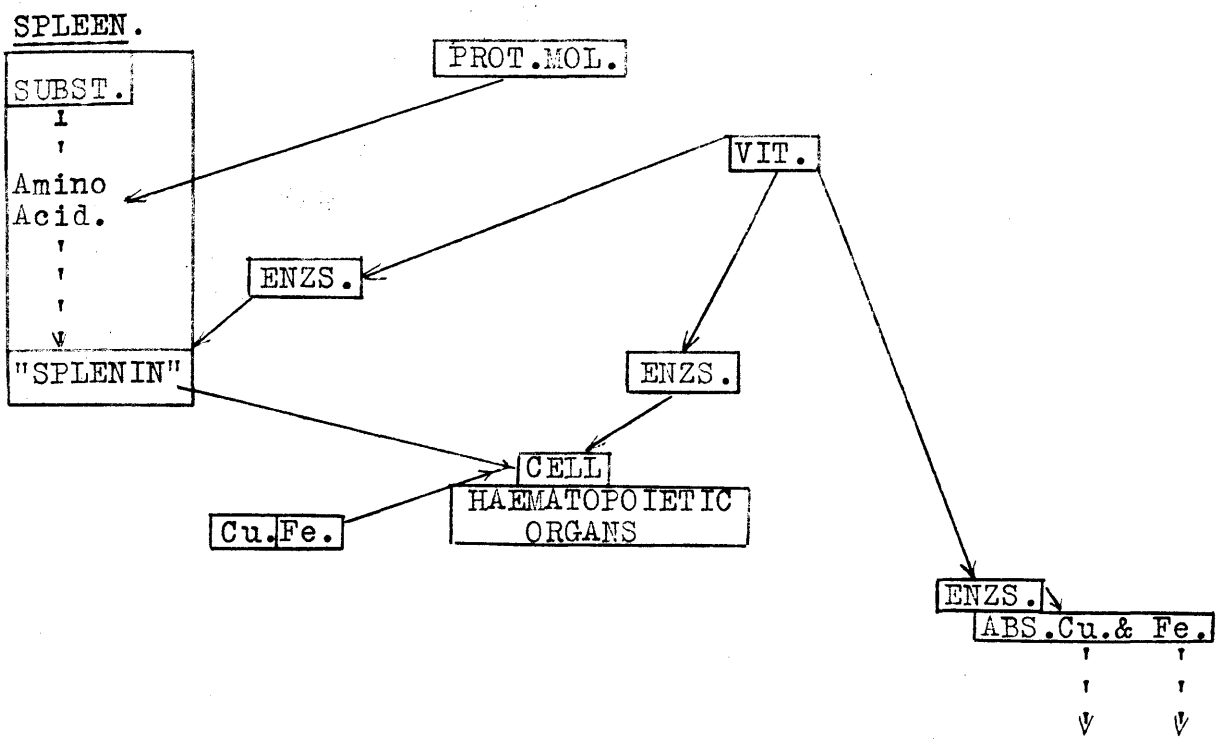
HYPO-FUNCTION.

The assimilatory power of insulin is decreased: diminished antagonism to dissimilatory effects of epinephrine → increased mobilization of glucose → hyperglycaemia → glycosuria.

Mobilization of body fats → storage in liver → lipaemia: incomplete combustion of glucose → incomplete combustion of fats → ketosis and acidosis.

One has seen marked glycosuria in diabetes clear up under U.-V. irradiation; it was not determined whether improvement was only temporary or permanent.

Insulin[9] gives a positive biuret reaction, showing its protein nature.

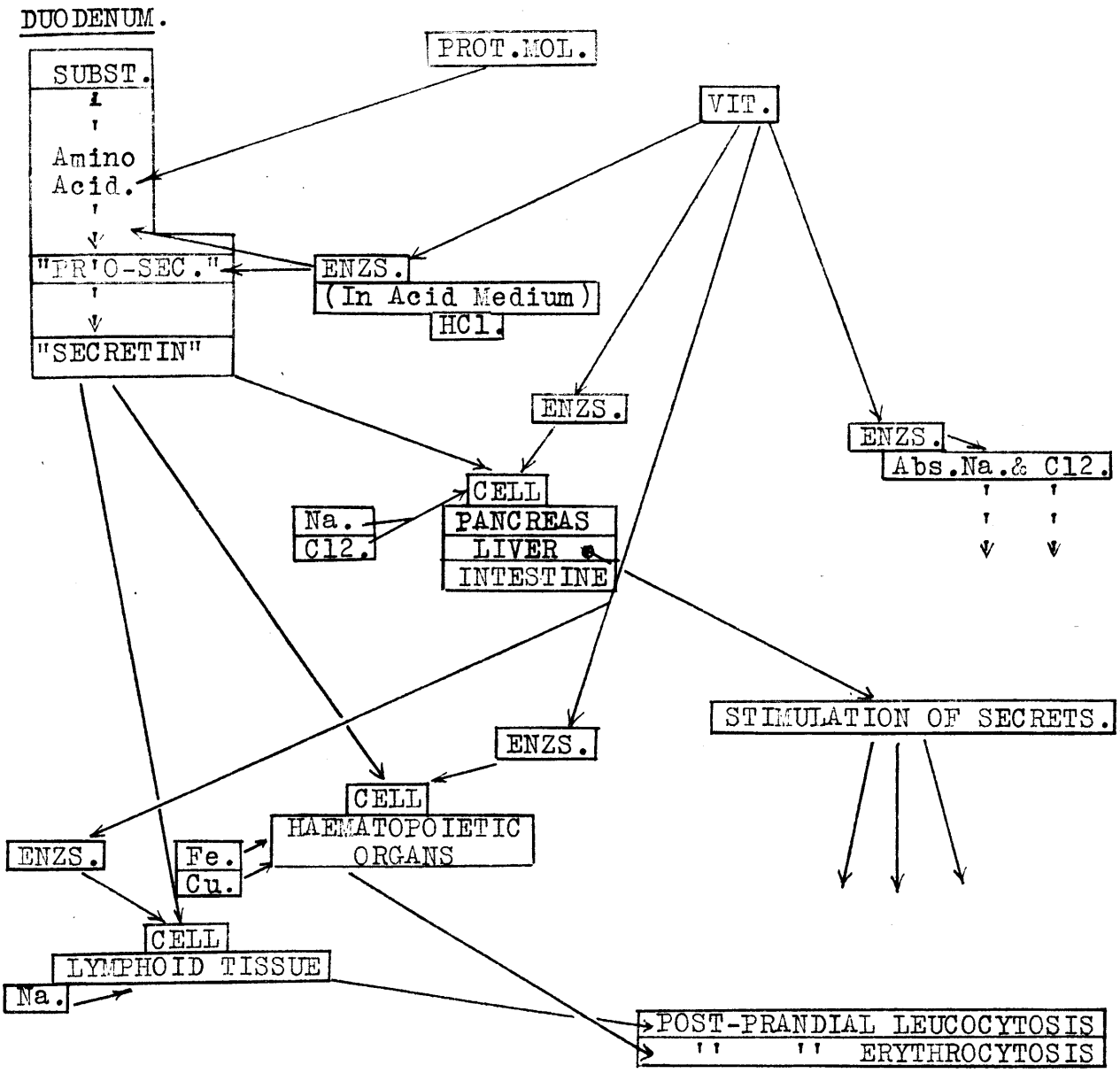


Marked improvement in red cell counts and haemoglobin content is a practically constant feature of irradiation treatment:one has noted increases of over two million reds,and 30% haemoglobin improvement in some cases after six treatments.Re-examination months later has shown maintenance of improvement.

The lymphocytosis noted after irradiation is due,in part, to the powerful thymus-stimulation.

There is said to be a polymorphleucopenia after irradiation:one would regard this as an apparent and not an actual decrease. Since the skin changes resulting from irradiation are acute,it is obvious that polymorphs will become concentrated in the skin, remaining in the "back waters" of the circulation during the period of congestion.

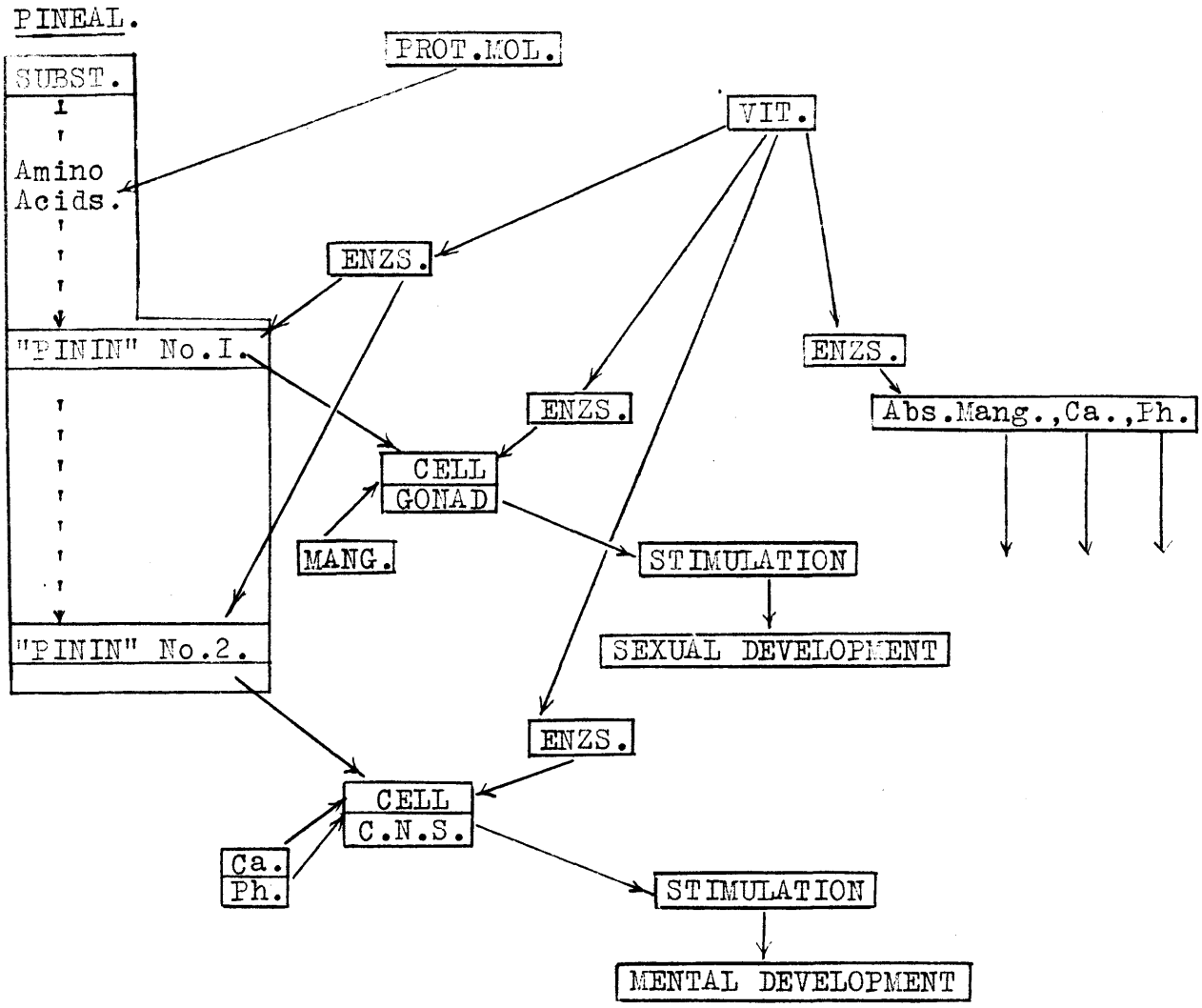
Eosinophilic leucocytes are also increased,while the blood platelets reach a normal concentration.
Animals kept in darkness and fed on a diet deficient in Vitamin A show reduction of platelets:on exposure to U.-V.rays,they are rapidly restored to normal:this,one would think,proves that the fat-soluble A is akin to cholesterol,and that it is elaborated in the skin as the result of irradiation.



One thinks it possible that secretin will have accompanying trephonic elements for the nourishment of the duodenal mucosa. Hypo-function would not only lead to various digestive disturbances, but also to defective nutrition of the mucosa: this may be a causative factor in duodenal ulceration!
One has seen cases of ulceration clear up clinically under U.-V. treatment.

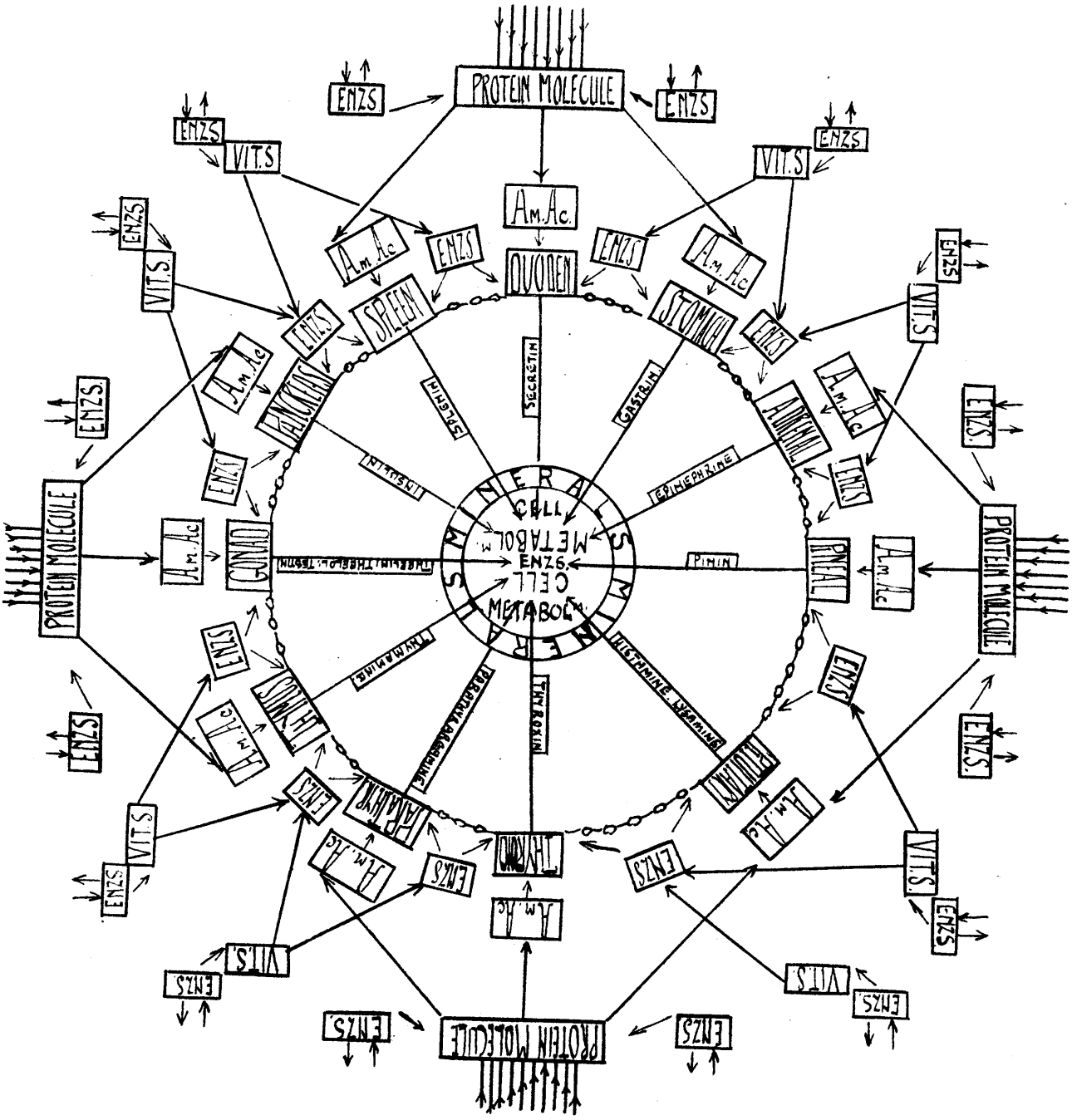
There may be a "Gastrin" secretion having somewhat similar functions, with special reference to the stomach.

(Two elements will be indicated).



The endocrine system constitutes a well-balanced organization, mutual antagonisms and synergisms existing as in the mineral system.
U.-V.radiations have been shown to exert marked regulatory effects on unbalanced systems,particularly in functional disturbances,the "shock" effects producing a re-organization of inter-relationships in a remarkably short time.
Hypo-states respond with great rapidity,especially when specific minerals are administered in conjunction with the rays.One is meeting with success in hypo-thyroidism which was resistant to prolonged glandular therapy;a special quinine-iodine colloid is given along with the rays.

DIAGRAMATIC SUMMARY.



CHAPTER SEVEN.

Clinical Manifestations Of Biological Activity.

CLINICAL MANIFESTATIONS OF BIOLOGICAL ACTIVITY.

SKIN.

(I).Temperature.

This is increased,the patient experiencing a warm glow all over the body.

(2).Erythema.

There are four degrees of reaction,viz:
(a).First Degree:

Very faint reddening after about six hours;disappearing in from one to two days,it leaves no visible exfoliation.

(b).Second Degree:

Mild sunburn reaction,reddening being plainly visible: subsiding in about three days,it is followed by slight granular exfoliation,and subsequent pigmentation.

(c).Third Degree:

Intense reddening:lasting about one week,it is followed by marked exfoliation and considerable pigmentation.

(d).Fourth Degree:

Intense reddening after about two hours,becoming more marked until exudation and blistering result.The reaction lasts for many days,being followed by marked exfoliation and pigmentation.
Since the true skin is not involved,scarring does not result.

(3).Pigmentation.

This usually becomes apparent after several moderate exposures.When due to the mercury-vapour arc,it is light yellowish-brown in appearance,while that resulting from exposure to the carbon arc is of a dark reddish-brown colour.

(4).Diseased Conditions.

Obvious improvement occurs,repeated erythema and desquamation resulting in the shedding of unhealthy skin.
In ulcerative and exudative conditions,excessive action by short wave-lengths leads to crust-formation,the longer regenerative radiations being hindered in their action: correct technique results in healing from below upwards.
Scarring is surprisingly limited.

BLOOD.

(I).Red Cells.

Simple anaemias react in a way that is almost specific: blood counts become normal after a few weeks's treatment,while haemoglobin %age is greatly increased.

(2).White Cells.

It is generally accepted that radiations below 3,300 Å. increase the lymphocytes by 2/3,000 per cmm.:this action is strong enough to counteract the diminution produced by X-rays.
In this lymphocytosis we have improved transportation of hormonic(and antigenic) and trephonic elements,with resultant increase in metabolic processes and antitoxic

effects.As mentioned previously,one regards the polymorphleucopenia as being apparent but not actual.

The increase in platelets is of importance in that these bodies are involved in processes of infection-resistance and blood-coagulation.
A reduction of these is seen in acute infections such as measles, influenza,and acute coryza,and in certain diseases associated with multiple haemorrhages (purpura etc.).
Increase occurs in pulmonary tuberculosis,the reason for this,one would think,being the absence of acute onset.

Improvement in platelets and calcium,and in the inter-relationship of these,will largely explain the beneficial effects of U.-V.rays in acute coryzas and in haemorrhagic conditions.Cell-membrane permeability will be regulated (not necessarily reduced), with beneficial effects on exudative processes,while the plentiful supply of necessary elements will ensure normal coagulability of the blood.

(3).Haemobactericidal Power.

This function can be brought to 100% efficiency by U.-V. radiations,the longer wave-lengths being most effective.
Experiments[10] have shown a 17% increase 2 1/2 hours after an erythema dose.
One is of opinion that the hormonic elements are able,by means of their side-chains,to link up with those of toxins,the latter elements being thrown out of action.They will also be capable of attacking the organisms themselves in a similar manner.
The general endocrine stimulation will lead to increased antitoxic and bactericidal powers.

(4).Mineral Content.

The serum content of calcium,phosphorus,iron,and iodine is increased,where these elements have shown previous deficiency.
Such improvement is demonstrable in tetany,rickets,anaemia,and hypo-thyroidism treated by U.-V.radiations.

(5).Sugar Content.

Sugar estimations show decrease in blood and urine content in cases of diabetes treated by the rays:a marked glycosuria often clears up completely.One is of opinion that permanent improvement in this state will depend on the presence of a certain amount of "Islet" tissue capable of stimulation.

(6).Chemical Reaction.

Regulation of mineral and general metabolism tends to normalize the hydrogen-ion concentration.

(7).Uric Acid Content.

This is considerably reduced,there being an abundant excretion of urates in the urine.In polyarthritic states,where the blood uric acid content is high and the urine content normal or subnormal,this action is very apparent.

CARDIO-VASCULAR SYSTEM.

(I).Hyperpiesis.

The vaso-dilatation affecting surface capillaries in the irradiated area results in dis-engorgement of underlying organs;congestive conditions in the viscera are thus relieved.The mechanism involved in this action has been described.

(2).Hypopiesis.

This condition improves considerably under U.-V. treatment:the usual associated symptoms of fatigue clear up with restoration of arterial tone.

(3).Cardiac Tone.

One has seen arhythmias disappear under treatment: this will probably be due to mineral adjustment, general metabolism stimulation,improved condition of the blood,and to the reduction of toxaemia.
Haemic murmurs disappear rapidly,while organic murmurs increase in intensity,showing improvement in heart muscle tone.
Anginal pains are often relieved,patients being enabled to increase their activities without discomfort.

NERVOUS SYSTEM.

(I).Analgesic Effects.

Such effects are usually rapid;one has seen lumbago, neuritis,arthritic pains,headaches,indigestion, colic,etc.respond during or immediately after irradiation.

(2).Sympathetic Nerves.

Spasmodic conditions (choreiform states) respond well,spasm being mitigated.
Besides beneficial arterial effects,improvement is seen in the excretory functions of the skin,and in temperature-regulation.Patients usually show trophic improvement,hair growing more abundantly,and the skin assuming a healthy appearance.

(3).Central Nervous System.

There is no doubt that marked mental stimulation takes place:children respond remarkably,becoming brighter at school,and taking a happy interest in their affairs.
Adults often show this improvement in increased capacity for mental exercise,and in the development of a retentive memory.

As mentioned earlier,one believes that improved mineral metabolism,with special regard to bromine, and possibly iodine,has much to do with the beneficial effects obtained in mental depression.
Certain mental conditions due to toxic effects,and to endocrine dis-harmony,improve considerably as the result of antitoxic action and endocrine regulation.

ALIMENTARY SYSTEM.

(I).Stomach.

One has seen stomach tone improve considerably as part of a general stimulation.
Improvement in appetite is obvious,while there is evidence of increased hepatic and pancreatic activity the general digestive processes being stimulated.
Ulcerative conditions respond well,often after failure of the usual methods:pain is relieved early in treatment.

(2).Duodenum.

One has produced clinical cure of duodenal ulceration in several cases:the circumstances ruled out the possibility of coincidential remission.

(3).Intestine.

Constipation is often relieved,increase in biliary function,and involuntary muscle-stimulation,playing a part.

PHYSIQUE.

(I).Muscles.

It is usual to find soft,flabby muscles firming up, the general contour of the body improving considerably:one has seen round-shouldered patients become quite erect,while the capacity for physical work is greatly increased:increased output of CO2 indicates improvement in muscle-metabolism.

(2).Bones.

The effectiveness of U.-V.radiations on the skeletal structure is epitomized in the cure of rickets,while tuberculosis of bone is another instance of their efficacy.

(3).General Growth.

One has observed the effects of U.-V.radiations on growth during the past three years:there is no doubt that these are considerable.

ENDOCRINE SYSTEM.

Thyroid stimulation is evidenced by the accelerated metabolism,while parathyroid,thymus,and gonad regulation are seen in the cure of tetany,rickets,and functional disturbances of ovary and testis.

The sum-total of U.-V.effects on the endocrine system is restoration of normal balanced function.

CHAPTER EIGHT.

U.-V.rays & Cod Liver Oil:

"Quinoidine".

RELATIVE MERITS OF U.-V.RADIATIONS & COD LIVER OIL.

Cod liver oil is an excellent source of Vitamin D.,but it cannot be regarded as a perfect substitute for U.-V.radiations,because the latter can be proved to be the more efficient in many instances:instead of being regarded as rivals,they should be used in combination,wherever possible,advantage being taken of both forms of treatment.

C.L.O.is less infallible than radiations in the prevention and cure of rickets:in some instances the oil is ineffective,ultimate cure being effected by the rays.An instance of this is seen in the Faroe islands and Iceland:"
Although anti-rachitic food is present in abundance in both places,the incidence of rickets is much higher in the former than in the latter because of the prevalence of thick fogs.

Since many patients are unable to assimilate the oil,its application is considerably limited:one has administered it in various forms,in certain cases,without success.

When one considers the "shock" tactics employed by radiations in their introduction to the system of vitamins and pro-hormonic elements,their greater effectiveness can be readily understood. Radiations are consequently more rapid in action,and cover a much wider range of utility.
It is apparent that C.L.O.is lacking in many of the properties possessed by the radiations;such properties include the rapid relief of pain,rapid healing of wounds and many skin affections, regulation of pathological blood-sugar,cure of gastric and duodenal ulcers,etc.,etc.

C.L.O.should not be disparaged,because its value is great,but, the value of Ultra-Violet rays is much greater,as has been demonstrated in the foregoing chapters.

"QUINOIDINE".

Many years ago Bence-Jones demonstrated the presence of "quinoidine" in the skin:this substance was extracted from the skin by boiling with HCl:it is generally regarded as a photo-dynamic element.

It may be of interest to note here that the writer had a quinine-iodine colloidal mixture tested in sixteen hopeless cases of malignant disease (Glas.& West of Scot.Med.Jour.),certain positive results being obtained: (June,1930)
Certain of the neoplasms showed marked retrogressive changes, while haemorrhages and ulcerations were favourably influenced: the general condition of a number of patients showed considerable improvement.
The mode of action of this mixture was undetermined:one has now come to regard it as having some connection with the quinoidine of the body,and to view the colloid as a sensitizer of certain cells to catabolic radiations.
In order to prove or disprove this connection,one is preparing to carry out quantitative and qualitative (spectroscopic) estimations of the quinoidine in malignant,hyperthyroidic,hypothyroidic,and normal subjects.

A case of hypothyroidism under treatment shows very marked blue fluorescence on irradiation:this may be due to excessive or deficient quinoidine-content.
The quinine-iodine mixture has been used in conjunction with the rays in certain cases complicated by a degree of hypothyroidism: results have been very good.

Ultra-Violet[12] radiations have been used in cases of malignant disease with beneficial effects as far as the general nutrition of the body is concerned:one thinks that a combination of U.-V. rays,X-rays (or radium),and the colloid would be worthy of a trial in malignant disease.

CHAPTER NINE.

Notes On Personal Cases.

During the past three years Ultra-Violet radiations have been used in the treatment of 270 cases, about 90% of the results being satisfactory,--a high therapeutic index.
The conditions dealt with include:

A. RHEUMATIC AFFECTIONS.

I. Osteo-arthritis: 2. Early Rheumatoid Arthritis: 3. Fibrositis: 4. Synovitis: 5. Neuritis: 6. Facial Neuralgia, and 7. Myositis.

B. RESPIRATORY SYSTEM AFFECTIONS.

I. Chronic Rhinitis: 2. Post-Nasal Catarrh: 3. Laryngitis: 4. Tonsillitis: 5. Chronic Otitis Media: 6. Chronic Bronchitis & Asthma: 7. Mild Bronchial Catarrh: 8. Pleurisy: 9. Whooping Cough, and IO. Mild Chronic Pulmonary Tuberculosis (Apical Catarrh & Glandular Infection).

C. BLOOD AFFECTIONS.

I. Simple Anaemia: 2. Pernicious Anaemia.

D. CARDIO-VASCULAR AFFECTIONS.

I. Hyperpiesis (Incipient Arterio-sclerosis): Hypopiesis (Hypo-Adrenal Function): 2. Angina Pectoris: 3. Arhythmias: 4. Debility.

E. NERVOUS SYSTEM AFFECTIONS.

I. Lateral Sclerosis: 2. Depression: 3. Hyper-excitability: Chorea: 4. Recklinghausen's Disease.

F. ALIMENTARY SYSTEM AFFECTIONS.

I. Pyorrhoea Alveolaris: 2. Stomatitis: 3. Lingual Ulcer: 4. Gastric & Duodenal Ulcer: 5. Chronic Mild Cholecystitis: 6. Diabetes: 7. Appendicitis: 8. Constipation.

G. GENERATIVE SYSTEM AFFECTIONS.

I. Dysmenorrhoea: 2. Menopausal Disturbance: 3. Pregnancy.

H. SKIN AFFECTIONS.

I. Boils: Abscesses: Carbuncles: 2. Eczema (Varicose): 3. Ulceration (Varicose): 3. Septic Wounds: 4. T. Barbae: 5. Pruritus Ani.

I. GLANDULAR AFFECTIONS.
ENDOCRINE.

I. Hypothyroidism: 2. Hyperthyroidism.

LYMPHATIC.

I. Simple Adenitis: 2. Tuberculous Adenitis.

The results of treatment in the above conditions have clearly demonstrated the wide range of utility possessed by U.-V. rays: the marked biological activity is due to their regulatory and general stimulative powers--factors of vital importance in the treatment of diseased conditions.

A. No claim can be made to cure in chronic osteo-arthritis:the improvement brought about in many cases is so marked,however, that considerable credit is reflected on the treatment. General irradiations stimulate endocrine action,thus increasing the metabolism of diseased products,while intense local treatment not infrequently results in mobilization of ankylosed joints;pain is markedly relieved.

In the earlier cases of rheumatoid arthritis one has seen a considerable number of clinical cures:those resistant to vaccine and other treatments have responded well to irradiations.Arsenic and iodide form an admirable combination with the rays in the treatment of such conditions.

Inflammatory conditions affecting fibrous tissues,synovial membranes,nerve-sheaths and muscles respond with a great degree of constancy.Fibrotic nodules disappear under strong local treatment,while benign joint effusions are rapidly absorbed:the latter is exemplified in a case of "Housemaid's knee" of about two months'duration:Various treatments had failed to cure the condition,pain and swelling persisting. Two strong exposures were given over the knee-joint,the condition undergoing resolution within five days.
Neuritic cases do well with combined I.R.and U.-V. rays,about five weekly exposures effecting cure in cases of moderate chronicity.
Facial neuralgia is often favourably influenced:example:- Condition of about fifteen years' duration;alcohol injections, nerve-resection,etc.,etc.,had given short respite.
Twenty four local treatments brought about complete disappearance of the pain:there has been no return in five months.
Myositis is an excellent condition in which to demonstrate the effectiveness of radiations in inflammatory states.One strong exposure will be sufficient in a recent case:pain sometimes disappears in the course of the treatment.

B. Ear,nose and throat conditions have been treated with considerable success:the very chronic rhinitis affections with marked septum deflection are difficult to clear up,results sometimes being disappointing;moderately severe cases,however, react very well to irradiation,mucous membrane infiltrations becoming absorbed,with opening up of the nasal passages;discharges are greatly decreased.
Eight local and general treatments have conferred immunity to hay fever for two seasons on a patient who had been a victim of this complaint for about ten years. 14.

The effectiveness of the rays in catarrhal conditions is greatly enhanced by the giving of general irradiations;calcium is a valuable adjunct.
One has seen patients who were martyrs to the "common cold" remain free of symptoms during the winter months.

Enlarged,septic tonsils can be reduced in size and rendered healthy:there is great scope for this conservative treatment, since it very often effects a cure:one is of opinion that operative treatment is unnecessary in the majority of cases. Associated otorrhoeic conditions react favourably.

Chronic[15] bronchitis and asthma with marked emphysematous change cannot be cured,but the symptoms can be greatly mitigated. Sputum is lessened,and breathlessness decreased,the general condition being much improved:patients are enabled to live through the winter months in comparative comfort.

Recent bronchial catarrh is easily influenced,a course of six treatments usually being sufficient to cure:relief from cough is obtained early in treatment.One has aborted an early bronchial "cold" with one exposure.

Pleurisy[16] can be aborted in its early stages by a third degree erythema dose over the affected side:fourteen such cases have been treated,only two requiring a further dose for relief of pain,which usually clears up by the second day.Crepitus disappears within a week.
A subsequent tonic course is of value in that it reduces susceptibility to the tubercle bacillus.
Most of the patients were able to attend work by the second or third day.
In the ordinary course of events the patient would be treated with poultices,antipyretics,and sedatives;convalescence would extend to two or three weeks,with the possible inititiation of an insidious tuberculous process.

As[17] far as one's experience goes,chronic mild pulmonary tuberculosis is very common.Such cases may be limited to the apex, or they may show slight generalized "woolly" mottling with emphasis in the region of the lung-roots.
One can claim that those conditions react in a specific way to U.-V.therapy;twenty five such cases have been treated successfully,clinical findings being confirmed radiologically in some instances.

A case[18] of whooping cough was favourably influenced by the rays, after pertussis vaccine had failed to affect the cough.Six exposures were given--at three-day intervals:"whooping" ceased on the day following the first treatment,the patient being able to sleep undisturbed.The period of convalescence was considerably reduced.

C. In every[19] case of simple anaemia treated,red cell-counts and Hb. contents have been normalized after six or ten irradiations: specific action of the rays can be claimed in such conditions. Examinations made a year later have shown maintenance of improvement.

Pernicious anaemia shows marked increase in red cells:in a case treated by rays and liver extract,the number increased from 2,300,000 to 4I/2 millions per cmm. after six exposures.There was great improvement in the general and cardiac conditions. This patient had been under treatment for six months without benefit,before the U.-V.treatment was given:the latter was undoubtedly the main cause of improvement.

D. Incipient[20] arterio-sclerosis is favourably affected by the radiations:blood-pressures have been reduced by as much as forty mm. Hg.,this improvement being maintained during the period of observation.One has seen the rays produce such effects when choline derivatives had failed to reduce the pressure:when combined with radiations,these chemicals act with greater rapidity in such cases as are amenable to their action.

Hypopiesis often responds to radiations alone,thus demonstrating their action on the endocrine system.

Angina[21] pectoris can be benefited,spasms becoming less frequent: patients are enabled to extend their activities without discomfort.A strong erythema is induced over the cardiac region:two such cases showed maintenance of improvement over a period of nine months.

One has seen irregularities due to underlying toxic factors undergo marked improvement with U.-V.treatment:concomitant cardiac debility disappeared with restoration of normal rhythm.

E. The anti-spasmodic effects of the rays were demonstrated in a case of lateral sclerosis. Various treatments had been used without effect; these included "Genoscopolamine", arsenic, iodide, and electrical treatments.
By the end of the course of ray treatment, the patient was able to walk unaided: spasticity was considerably reduced, while the knee-jerks became much less active. Improvement was maintained for six months: no further U.V. treatment was given.

Mild[22] degrees of mental depression have responded to the treatment: one has seen such cases associated with indefinite symptomatology clear up completely. The regulation of some subtle influences probably reflected favourably on the mental state.

Choreiform[23] movements affecting the left shoulder in a female aet. 31 are showing signs of mitigation under treatment: the general nervous condition is also improving. This patient had been under treatment for many years with negative results. Septic tonsils are being treated, this probably accounting for a certain amount of the improvement.

U.-V. and I.R. rays were used in an endeavour to relieve the excruciating pain in a case of Recklinghausen's disease: tumours on the sciatic nerve had increased greatly in size, thus adding to the pressure symptoms. Deep X-ray therapy had given negative results.
U.-V. gave relief for about a day at a time, the pain gradually regaining its former intensity.
Subsequent operation showed the tumours to be sarcomatous: the case terminated fatally with sarcoma of the lung.

F. Pyorrhoea[24] has been treated successfully: moderate degrees of infection can be definitely cured. The rays have a direct bactericidal effect on the causal organisms, being conveyed to the apices of pus-pockets by means of a fine curved applicator. Earlier forms of the disease can be cleared up completely with five or six treatments: the white rays are used for their bactericidal effects, these being followed by the blue regenerative radiations.

Stomatitis and lingual ulcer have been rapidly cured by means of local irradiation: causal organisms are killed directly, regeneration being effected by the blue rays. Such cases were resistant to paints and mouth-washes, as well as to general tonic treatment.

Gastric[25] ulcer has shown every sign of clinical cure: one case treated medicinally for six months without relief of pain or flatulence showed complete disappearance of pain after the second irradiation. In this case six treatments were given: nine months later the patient was still free of pain, while flatulence was almost completely absent.

Duodenal ulcer may be similarly affected: one has treated five such cases which were resistant to medicinal and dietetic measures: clinical cures were obtained, co-incidential remission being unlikely in every case.
Relief of pain is a marked feature, and usually occurs early in treatment: radiations are concentrated over the epigastric region.

Three cases of chronic mild cholecystitis have been relieved of all symptoms: I.R. and U.-V. radiations were combined in their treatment. There is no doubt that the underlying catarrhal condition was favourably influenced in each case.

Two[26] cases of diabetes treated by radiations alone showed complete disappearance of glycosuria under treatment: the general condition was improved.
Improvement was maintained during six weeks' treatment.

A case of chronic appendicitis complicated by a serious heart condition was treated by I.R.and U.-V.rays while the patient was being"built up"for operation.X-ray confirmed the diagnosis. During the treatment,pain was greatly reduced,and tenderness became less marked.
At operation it was seen that the appendix had improved considerably,when the findings were compared with those of the X-ray examination.

Many patients having general treatment find that constipation is relieved:this will result from general stimulation of the various functions,and from augmentation of intestinal muscle action.

G.A considerable number of patients undergoing general treatment are agreeably surprised to experience regulation of disturbed menstrual functions:the pre-existing trouble is mentioned,in some cases,only when regulation has occurred under treatment. Improvement in gland-balance and blood condition are largely responsible for correction of the menstrual function.

Menopausal[27] disturbances--flushings,palpitation,nervousness,etc.-are frequently regulated,the action being one of balance-restoration:one has seen a case in which the mensis had been absent for several months--with aggravation of the symptoms--return to regular periods for a few months--with mitigation of the symptoms--this being followed by complete cessation,and gradual diminution of disturbing symptoms.

A case irradiated during pregnancy is worthy of note:
Tonic doses were given at intervals during the period of gestation:six weeks before delivery,X-ray showed full-time development of the foetus;the centres of ossification were well marked. The general tonic effects of the rays were seen in the mother's freedom from the more common signs of pregnancy--coarseness of skin,calcium-drain,etc.,etc.
Galactagogue effects were evidenced by the presence of an abundance of very rich milk.

Such pre-natal irradiation,if carried out as a matter of routine,would lead to the complete disappearance of rickets,etc.

H.Boils,abscesses,and carbuncles are very amenable to U.-V.treatment:general treatment,when given along with local irradiation, is of great value in the immunizing of patients to such conditions. If the infection is attacked early,abortion of the process occurs:when the condition has fully developed,the rays accelerate discharge of pus,healing taking place with rapidity:scarring is remarkably slight.Pain is relieved early in treatment.

Varicose eczema reacts well:one uses the white rays at first for abiotic effects,changing to the blue regenerative rays when the superficial layers have scaled off.Several patients seen a year after treatment have been free of symptoms.

Pruritus[29] ani sometimes improves with intense local treatment: it is advisable to incorporate general treatment.
A case treated has shown fifty per cent improvement:the main sources of irritation at the moment are fibrous tags at the anal orifice;these will be treated by X-ray.

Three cases of T.Barbae were treated with the white rays under compression:all the involved areas were given erythema doses. The symptoms disappeared completely within a week.

Varicose ulcers may be healed with a few treatments:one has treated seven of these,obtaining cure in each case.Two cases showed relapse some months later:further treatment again resulted in healing.The others remained healed.

29
I. Varying degrees of hypothyroidism are met with in practice: several gross examples have been treated with good results. One patient, who had been taking large doses of thyroid without result, had her treatment augmented by U.-V. radiations: the weight was reduced by 18 1/2 pounds in eight weeks, the patient feeling much better in general.

30.
Only one case of exophthalmic goitre was treated; it was complicated by persistent bronchial catarrh. A feature of this case was spasmodic contractions of the right sterno-mastoid. The pulse-rate was 120 per minute. The catarrhal condition cleared up during treatment, and the spasmodic movements of the head became less marked, but, there was no decrease in the pulse-rate. Subsequent operative treatment resulted in reduction to 90. There was a family history of Grave's disease.

Several cases of benign adenitis have been treated, resolution occurring rapidly in each case: in one instance a submaxillary gland had been swollen and indurated for about a year; complete disappearance of the swelling followed tonsillar irradiation.

31.
Three patients with cervical tuberculous adenitis were treated successfully: in two of these prolonged local and two short general courses reduced the swellings to small fibrous knots. In the other case the rays accelerated discharges, healing taking place with a minimum of scarring.

CHAPTER TEN.

Summary & Conclusions.

PHYSICAL EFFECTS.

Radiations induce electronic disturbances in the ether, oscillatory movements resulting which propagate the radiations toward the earth in the form of waves of electrical energy, these waves differing in length and vibrational frequency.

Such radiations have their presence demonstrated and their intensity measured by the reactions which they induce in special substances.

Radiations are absorbed in varying degree when incident on different substances: each wave-length penetrates the substance to the depth at which its affinity is situated.

Substances vary greatly in their powers of reflecting radiations, the degree of reflection shown by a particular substance depending on its absorptive powers.

Fluorescence is the expression of active isomeric changes in the substance on which the radiations are incident, the repelled radiations being greater in length than those incident, because their energy has been increased as the result of the reaction.

CHEMICAL EFFECTS IN THE PLANT.

Radiations induce synthetic and reductive processes in the plant, in the presence of favouring factors--gases, minerals, and sensitizing elements.
Analogous changes occur in the animal organism, radiations necessary for their fulfilment being derived from food.

CHEMICAL EFFECTS IN THE ANIMAL ORGANISM.

Direct irradiation of the body initiates and maintains high-velocity electro-chemical reactions of the nature of "shock" effects, such changes being induced in a structure which is the site of many and varied functions by groups of radiations which are physically blended but functionally different.

Reductive processes are seen in the disruption of the protein molecule with liberation of its amino acids, while the local activity of these is demonstrated in erythema-production.

Other local activities of radiations become manifest in the production of analgesic and pigmentatory effects.

Synthetic processes occur in the regeneration of damaged tissue and in vitamin elaboration.

The general activities of the radiations are seen in effects on the intimately associated minerals, enzymes, hormones, and trephones of the body, the end-result of such activities being normalization of inter-relationships and balances.

Hormone synthesis results from interaction of endocrine substance and absorbed amino acids, every vital bodily function thus being directly or indirectly influenced by incident radiations.
Through this connection radiations are able to stimulate processes governing growth of the organism in all its departments, both mental and physical. Such biological activity has been clearly demonstrated in a practical form.

Bearing in mind the gist of the foregoing chapters, the obvious conclusion is that Ultra-Violet rays constitute the most versatile and potent therapeutic weapon in the armamentarium of the modern clinician.

U.-V. radiations are not a panacea, but they are the nearest approach to it of any therapeutic measure adopted at the present time.

It would be unwise to neglect medicinal and dietetic measures in the practice of Actinotherapy: the rational form of treatment consists of a combination of these.
The giving of iodides, bromides, calcium, etc., etc., expresses the desire to rehabilitate the minerals of the body and through them to influence the endocrine and other functions--iodides in inflammatory conditions to induce absorption of abnormal tissue through enhanced thyroid action: bromides to influence mental disorders through endocrine action: calcium to restore normal parathyroid efficiency, etc., etc.

Dietetic measures are adopted with a view to relieving strain on an organ/s disturbed in some way--exclusion of eggs in kidney disease: reduction of sugar in diabetes, etc., etc.

Medicinal and dietetic measures may yield negative results, the cause of failure being in the absorptive and assimilative processes: since radiations have specific stimulative effects on such processes, their administration will remove the factor causing this failure and thus produce the desired effects.

Returning to the simile--radiations constitute the "super-charger" of the engine, speeding up activity and energy-utilization in the performance of every function.

Combined treatment means reduction of strain on weak parts, and abundance of fuel which is used to the best advantage.

The value of Ultra-Violet rays in therapeutics has been proved.

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