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— 目 次 —

GTR 法について.....	末 田 武	1
明治初期の系統解剖学書 .....	島 田 和 幸	15
免疫系の抗原認識と特異性 .....	伊 藤 博 夫	23
Early Buddhist Ethics and Modern Science: Methodology of Two Disciplines .....	Shoyo Masako Taniguchi	35
1997年鹿児島大学歯学部 SCI 発表論文リスト .....		63

鹿 齒 紀

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1. 本誌は歯科医学の研究や教育に関して特定のテーマに基づき、総説あるいは啓蒙的・解説的な論文を主体に掲載する。本学部の教官は下記の規定に従い、誰でも投稿することが出来る。投稿論文の採否は、編集委員会が決定する。
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  5. 和文原稿はA4版またはB5版400字詰め原稿用紙を用いて書き、英文原稿はA4版用紙に10ピッチ、ダブルスペースでタイプする。別にコピー部をつける。原稿をワープロで作成した場合は、フロッピーディスクをつける。
  6. 表紙(原稿第一枚目)には、1)表題、2)著者名、3)所属、4)欄外見出し(和文25字以内)、5)図表の数、6)原稿の枚数、7)別刷請求部数(朱書)、8)編集者への希望などを書く。
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例1: 3) 前田敏宏, 渡辺 武, 水野 介, 大友信也: B型肝炎ウイルスに対するモノクローナル抗体. 細胞工学, 1, 39-42, 1982

例2: 1) Hodgkin, A. L. & Huxley, A. F.: The components of membrane conductance in the giant axon of *Loligo*. J. Physiol. (Lond.), 116, 473-496, 1952
  - 4) 単行本は著者名, 書名, 版数, 編集名, 章名, 引用頁, 発行所, その所在地の順に記す。論文集などの場合は雑誌に準じるが、著者名: 章名, 書名, 版数, 編集名, 引用頁, 発行所, 所在地, 西暦年号の順に記す。

例1: 金子章道: 視覚; 感覚と神経系(岩波講座現代生物化学8), 初版, 伊藤正男編, 38-57, 岩波書店, 東京, 1974

例2: McElligott, J. G.: Chap 13, Long-term spontaneous activity of individual cerebellar neurons in the awake and unrestrained cat., In: Brain Unit Activity during Behavior, 1st ed., M. I. Phillips, Ed., 197-223, Charles C. Thomas, Springfield, 1973
  - 5) 孫引きの場合は原典とそれを引用した文献及びその引用頁を明らかにし、“より引用”と明記する。
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12. その他  
集会などの内容紹介, 海外だより, ニュース, 討論, 意見, 書評, 随筆など歯科医学または歯科医学者に関係あるあらゆる投稿を歓迎する。全て図表, 写真などを含めて400字詰め原稿用紙5枚以内にとまとめる。但し, 採否は編集委員会が決定する。

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# GTR 法について

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GTR 法とは英語の Guided Tissue Regeneration の各語の頭文字をとった略称であり、日本語では組織再生療法と言われている。この治療法は1980年代の半ばから歯周治療の分野で、1990年代に入ってからインプラントとの分野でも行われるようになった。本文では GTR 法が開発されてきた経過と、現在行われている術式などを中心に述べる。

## 1) 歯周治療における GTR 法

歯周治療の対象になるのは歯周病である。歯周病は歯周組織を侵す病変の総称であり、一般的に見られるのは単純性歯肉炎と慢性辺縁性歯周炎である。歯周組織の模式図を図1に示す。歯肉は上皮組織と結合組織からなり、正常な場合、歯と接している上皮組織は歯冠を形成しているエナメル質とハーフデスマゾーム結合している。上皮組織の最根尖側（最下方）の位置はエナメル質とセメント質との境である。歯と接している歯肉結合組織は、結合組織中のコラーゲン線維がセメント質中に入り込むことにより、セメント質と線維性結合をしている。歯槽骨の頂部はエナメル質下端よ

り約1-2mmに位置している。歯根膜のコラーゲン線維の一端はセメント質中に、他の一端は歯槽骨中に入っていて、歯は歯槽骨に固定されている。このように歯と歯周組織との結合には上皮性の結合と線維性の結合がある。線維性の結合を一般に結合組織性結合と呼んでいる。結合力は結合組織性結合の方が勝っている。

歯周組織に病変が最初に見られるのは歯肉である。多くの場合、炎症を主体とした病変で、歯肉炎と呼ばれている。歯肉炎の大多数は慢性経過をたどり、この病変を単純性歯肉炎と称している。この状態では歯と歯周組織の結合組織性結合状態に大きな変化はない。歯肉炎の病状が進展すると慢性辺縁性歯周炎になる。即ち歯肉炎症の影響により歯周組織の崩壊が起こる。歯槽骨が吸収し、それに伴って歯根膜が消失し、歯肉線維の付着部位は根尖方向（下方）に移動し、歯肉上皮の歯に付着している部位も根尖方向（下方）にその位置を変える（図2）。このような状態になると結合組織性結合の一部が消失する。

慢性辺縁性歯周炎に対して、さまざまな治療が行われてきている。歯肉の炎症を消退させ、疾病の再発を

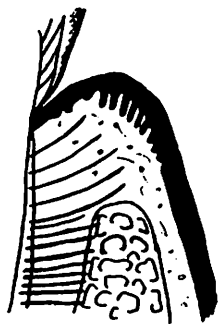


図1 健全な歯周組織では上皮はエナメル質とのみ接し、歯肉と歯根膜の結合組織はセメント質と結合している。

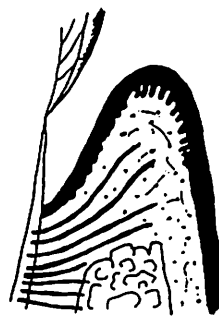


図2 辺縁性歯周炎では歯肉と歯根膜の結合組織性結合が失われ、セメント質が口腔内に露出し、歯槽骨の吸収が起こる。



図3 重度歯周炎患者の初診時の状態。歯肉炎症が見られ、深い歯周ポケットが存在していた。

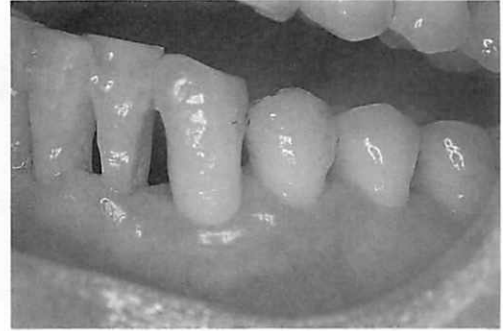


図4 ブラークコントロール、スケーリング・ルートプレーニング、歯肉剥離掻爬術などの歯周治療が終了して約2年経過した時の状態。大きな歯根露出が見られる。

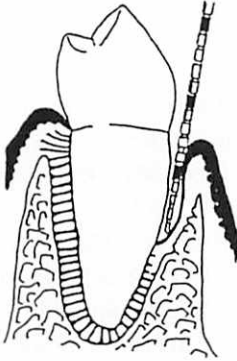


図5 辺縁性歯周炎の状態では線維性結合が失われている。

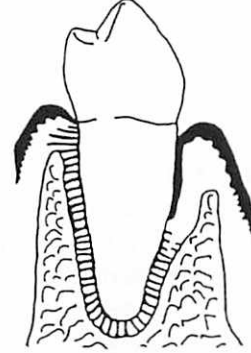


図6 一般に行われている歯周治療を行った後の状態。結合組織性の結合は起こらず、上皮性の結合のみが見られる。

表1 猿に人工的に歯周炎を惹起し、各種術式を行った後の新付着の比較。

グループ	N	実験部位	コントロール部位	P
MWF	22	3.38	3.51	NS
MWF + 自家骨移植	14	3.16	3.12	NS
MWF + Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> 移植	14	3.36	3.40	NS
ルートプレーニング + キュレタージュ	22	3.05	3.08	NS

数値は CEJ から接合上皮の最根尖側までの長さを mm で表わしている。  
MWF は modified Widman flap operation の略。いずれの術式においても新付着は認められていない。

防止することは出来るが、何れの治療法を用いても崩壊した結合組織性結合を再生させることは出来ない(図3, 4)(表1)。その模式図を図5, 6に示す。

1970年代後半からは崩壊した結合組織性結合を再生させる研究が行われてきて、1880年代後半に結合組織

性結合を再生させることが可能になった。その研究を通じて次のようなことが分かり、それらの結果が臨床に応用されるようになり、GTR法が確立した。また実験を通じて再付着(生存している歯周韌帯が存在している根面と結合組織との再結合)と新付着(歯周韌



図7 病変部に歯肉剥離搔爬術を行ったとき、歯根面に來る可能性のある細胞（歯肉上皮細胞、歯肉結合組織細胞、骨芽細胞、歯根膜細胞）を矢印で示す。



図8 上皮細胞が根面に來たときの状態を示す。歯と上皮との間に長い上皮性の結合が見られる。



図9 歯肉結合組織細胞が根面に來たときの状態を示す。根吸収が起きる。



図10 骨芽細胞が根面に來たときの状態を示す。骨性癒着と根吸収が起きる。

帯が失われた根面と結合組織との再結合）がはっきりと定義されるようになった。歯肉剥離搔爬術を行った後、歯肉弁を戻した場合、歯根表面に到達する可能性のある細胞は図7に示すように、歯肉上皮細胞、歯肉結合組織細胞、骨芽細胞、歯根膜細胞である。上皮細胞が歯根の表面に最初に到達した場合、図8に示すように長い上皮付着が形成され、結合組織性結合は見られない。一般に行われている歯周治療での治癒はこの形態になる。歯肉結合組織の細胞が最初に歯根の表面に到達すると、歯根の表面に沿って歯肉結合組織が形成される。歯肉結合組織細胞はセメント質形成能を有していないので、歯根の表面にセメント質が形成され

ることはなく、歯根の吸収が起きる（図9）。骨芽細胞が歯根の表面に最初に到達すると歯根に沿って歯槽骨が形成され、歯根と骨性癒着が起こり、歯根吸収が起こる（図10）。歯根の表面に歯根膜細胞が最初に到達すると、歯根の表面にセメント質が形成され、線維性の結合が得られる。ついで歯槽骨の再生が起こることも判明した。即ち、結合組織性結合の再生を得るためには歯根の表面にセメント質を再生させ、そのセメント質中に線維が入り込まなくてはならない。このことより如何にして歯根膜細胞が歯根の表面を覆うように出来るかが検討され、歯根膜細胞が歯根の表面を覆うまで、歯肉の上皮細胞と結合組織細胞が歯根の表面



図11 遮断膜を用いた場合の状態を示す。始めに歯根膜の細胞が根表面に来た後、セメント質、歯槽骨、歯根膜の再生が起きる。

に出来ないようにすることが結合組織性結合を再生させるのに大切であることが解明された。その方法として遮断膜を用いる方法が開発された(図11)ことによりセメント質、歯根膜、歯槽骨の再生が可能になり、臨床でもこの遮断膜を用いる方法が行われるようになった。これが現在行われている GTR 法である。

## 2) 歯科インプラント治療における組織再生

歯が何らかの理由により抜去されたとき、口腔の機能を回復する目的で、抜去された部位に人工の歯を入れることが行われている。従来よりその処置として可撤式義歯(取り外し可能な義歯)と固定式義歯(ブリッジ)を入れることが行われてきている。最近これらの方法とは異なる人工歯根を利用する歯科インプラントが用いられ、歯が欠損した部位の補綴が行われるようになった。人工歯根は骨と直接結合する材料で作られ、歯槽骨の中に埋入される。この上部に可撤性義歯の保持装置や人工歯が作られ口腔の機能の回復が計られている(図12)。人工歯根が用いられるようになったが、その適応範囲は限られていた。すなわち歯槽骨頂部が人工歯根の直径よりも幅が狭い場合、人工歯根を適応することが不可能である。この適応範囲を広げるために、骨移植を用いる方法や、歯周治療で用いられていた遮断膜を用いる方法が検討され、インプラント用の遮断膜が開発された。この膜の使用法の模式図を図13、14に示す。この方法を一般にはGBR法あるいは骨誘導再生法と呼んでいる。遮断膜は人工歯根周囲に粘膜の結合組織が来るのを防止し、その部位に骨芽細胞が出現し歯槽骨が再生することを期待して用いられてい

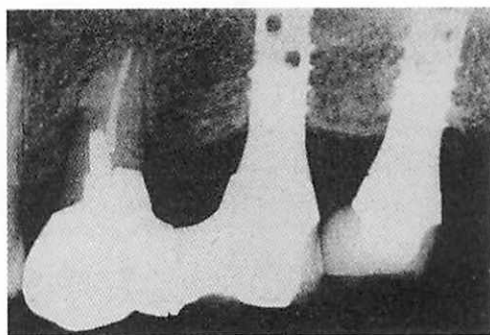


図12 補の欠損部に人工歯根が埋入され、その上部に人工歯冠が装着されている状態(X線像)。

る。

## 3) 遮断膜

遮断膜には歯周治療に用いられる遮断膜と歯科インプラントに用いられる遮断膜があり、その形態は異なっている(図15、16)。遮断膜はその素材により生体内で分解されない非吸収性膜と、生体の中で分解吸収される吸収性膜とに分類されている。非吸収性膜を使用した場合、膜を生体内にいれたまま放置することができないので膜を取り出す2次手術が必要になる。しかし膜が口腔内に露出するようなトラブルが生じたときには膜を取り出せるという利点もある。膜の素材はTeflonであり、膜はこの素材を伸展させ多孔性の形状にした expanded polytetrafluoroethylene である。インプラント用の遮断膜は非吸収性である。吸収性膜を使用した場合、生体内で分解吸収されてしまうために2次手術の必要はない。しかし、膜が口腔内に露出した場合、取り出すことが出来ないため、色々なトラブルの原因となる。現在、吸収速度の問題などで歯科インプラント用の膜として一般に認められている膜はない。素材として高分子化合物を使用したものと、コラーゲンをういたものがある。高分子化合物を応用した膜にはポリ乳酸・ポリグリコール酸の共重合体、ポリ乳酸とクエン酸化合物、ポリ乳酸・グリコール酸の共重合体とポリ乳酸との2重構造になっているものなどがある。コラーゲンをういた膜では再生コラーゲンが用いられている。

この両方の膜は次に述べるような性質を有していることが求められている。その性質とは生体親和性、組

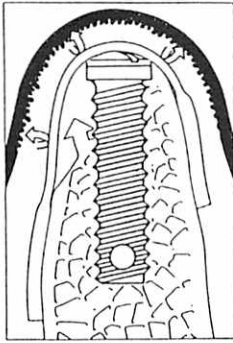


図13 インプラント周囲に骨が不足しているときに遮断膜を設置した状態。作成したスペース内に粘膜の結合組織が増殖しないようにし、骨で満たされるのを期待している。

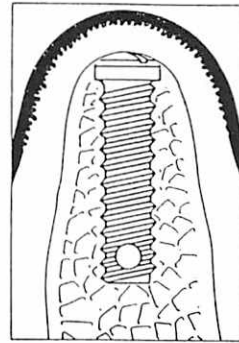


図14 インプラント周囲に骨ができた状態。

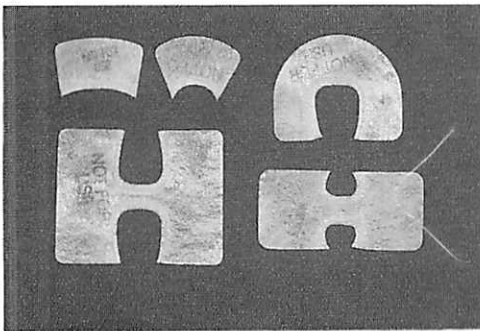


図15 歯周治療用の遮断膜。

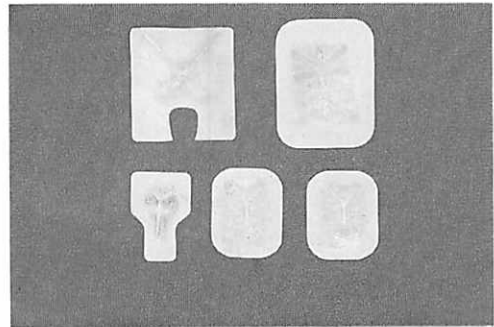


図16 インプラント用の遮断膜。

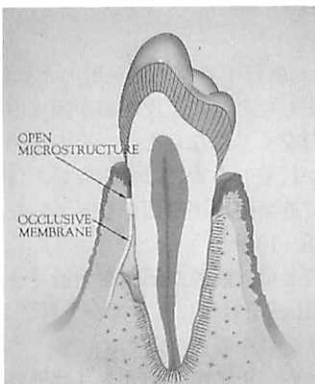


図17 歯周治療用遮断膜による上皮の歯根側への増殖を防止する状態を示す模式図。

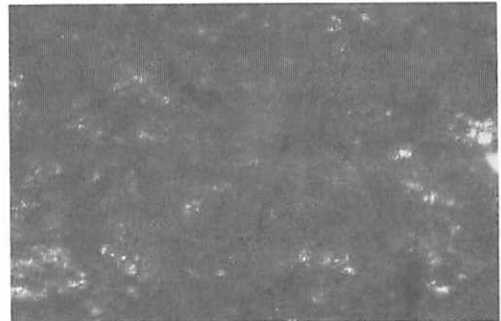


図18 表面が平滑でない多孔性の遮断膜上多孔性のヒト歯肉線維芽細胞を培養した状態。線維芽細胞が伸展している状態を示す。

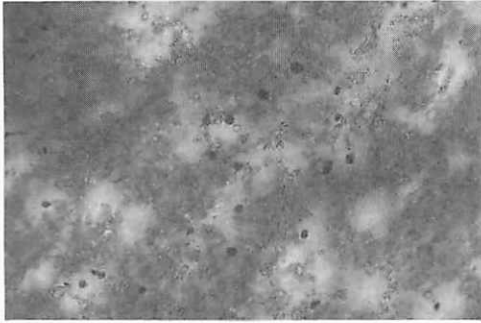


図19 表面が平滑な遮断膜上でヒト歯肉線維芽細胞を培養した状態。線維芽細胞が伸展しないで球状を呈している。

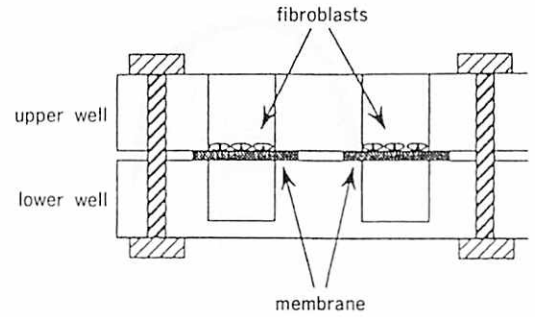


図20 ケモタキシスチャンパーを用いて細胞遮断性を調べた実験の模式図。アッパーウエルにヒト歯肉線維芽細胞を播種し、ローアーウエルに透過してきた細胞数を調べ透過率とした。

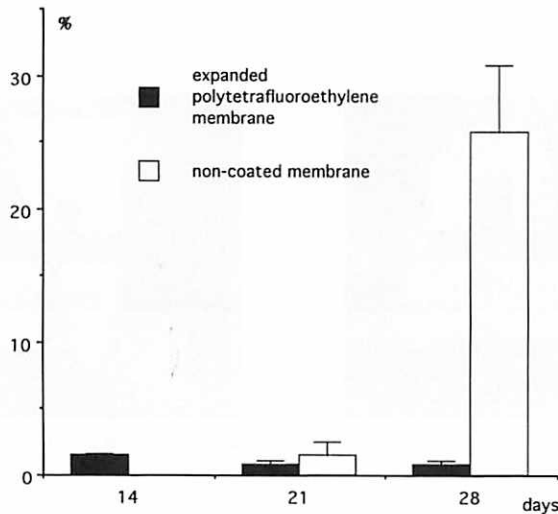


図21 図20で示した実験の結果を示す。白いコラムは吸収性膜の細胞透過性を、黒いコラムは非吸収性膜の細胞透過性を示す。吸収性膜の細胞遮断性が28日目には失われているのが分かる。

織統合性、細胞遮断性、スペースメーカー、臨床的に良好な操作性を有することである。

遮断膜が生体親和性を備えるということは遮断膜は生体のなかに封入されるので、膜と周囲組織との間に患者が不利になるような反応を生じさせない、即ち安全性があり、意図した治療を得るということである。安全性の中には免疫応答も含まれ、遮断性膜が抗原性を示さないことが求められる。

組織統合性とは遮断膜と周囲組織が付着し、組織の安定を計り、上皮組織の侵入を防止する機能を意味している。剥離掻爬術を行った後、歯面に沿って上皮組織が根尖方向に増殖してくるが、歯周治療用の遮断膜はこの増殖を膜の歯冠側の部位で阻止しなくてはなら

ない(図17)。歯科インプラント用の遮断膜では膜が口腔内に露出したときに上皮組織が膜に沿って増殖するのを阻止しなくてはならない。そのためには遮断膜に結合組織が付着しなくてはならない。付着するための条件として遮断膜は平滑面を有していなければならない(図18, 19)。

細胞遮断性とは遮断膜が細胞を通過させない機能を意味し、GTR法を行うには必要な条件である。遮断膜には組織統合性を維持するために多くの場合多孔性になっているが、その小孔の大きさは細胞を通過させない大きさになっていなくてはならない。遮断膜が生体内で分解吸収される場合、細胞遮断性のある一定期間維持しなくてはならない(図20, 21)。



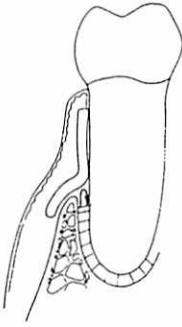


図22 遮断膜の下に組織が再生するスペースがない状態を示す。

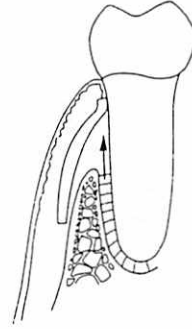


図23 遮断膜の下に組織が再生するスペースが確保されている状態を示す。

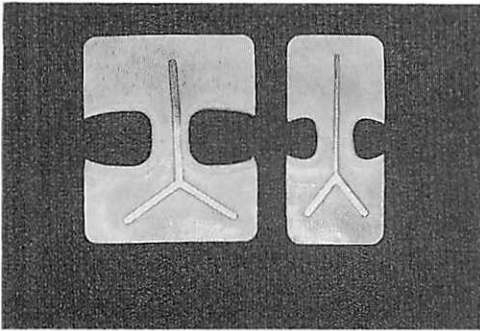


図24 チタンを封入した非吸収性膜。



図25 GTR法を行う直前の口腔内写真。ポケットの深さ、アタッチメントロス共に5mmである。

希望する組織を遮断膜の下に増殖させるための空間を作成し、それを維持するのをスペースメイキングと呼んでいる。遮断膜は当然この機能も具備していかなくてはならない(図22, 23)。非吸収性膜には生体内に埋入した時、陥没しないようにチタンを膜内に封入し、強度を上げているものもある(図24)。

遮断膜の臨床での操作性には手術中の膜の取り扱いやすさ、術後の管理のし易さが焦点になる。

#### 4) 臨床術式

現在歯周治療に用いられるGTR法の適応範囲はかなり限られている。適応症として認められているのは根分岐部病変のうち2度のもの、垂直性骨欠損のうち2壁性骨欠損、3壁性骨欠損、カップ状骨欠損である。辺縁性歯周炎で最も多く見られる水平性骨欠損は適応症にはなっていない。局所麻酔を行った後、歯肉溝内切開を入れる。縦切開を該当歯より1歯ないし2歯離

れた部位に入れる。歯肉弁を全層弁で形成する。この際歯肉組織を除去しないよう気を付ける。歯面のスクーリング、ルートプレーニングを行い、肉芽組織を除去する。非吸収性の膜、吸収性の膜のある種の場合は直接膜のトリミングを行う。吸収性膜のある種の場合は試適膜でトリミングを行い、吸収性の膜をトリミングした試適膜と同じ形態にする。遮断膜を歯面に密着するように設置する。歯肉弁を元に戻し、遮断膜を完全に覆うようにし、歯肉弁を縫合する。吸収性膜を使用した術式を図25-33に示す。非吸収性膜を設置した状態を図34-36に示す。非吸収性膜を使用した場合、膜設置後4~6週後に歯肉弁を作成し、膜を除去する。その際膜の下に形成されている肉芽組織を保存し、その肉芽組織を歯肉弁で覆う。6カ月後よりプロービングすることができる。X線写真上で骨の形成が確認できるのは約1年後からである。

GTR法を歯科インプラントに適応するのに2つの



図26 歯肉弁を形成し、スケーリング・ルートプレーニング、肉芽組織の除去が終了した状態、口蓋側にカップ上の骨欠損が見られる。

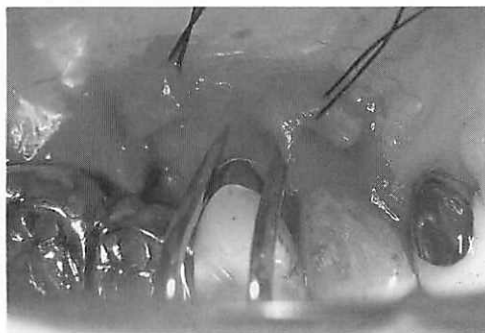


図27 試適膜が歯頸部と適合するかを調べている状態。



図28 試適膜のトリミングが終了した状態。

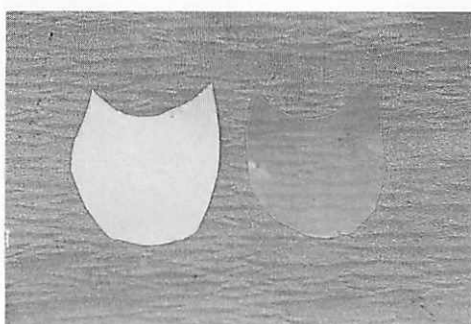


図29 試適膜と同じ形態になるように遮断膜を切り出した状態。左が試適膜、右が遮断膜。

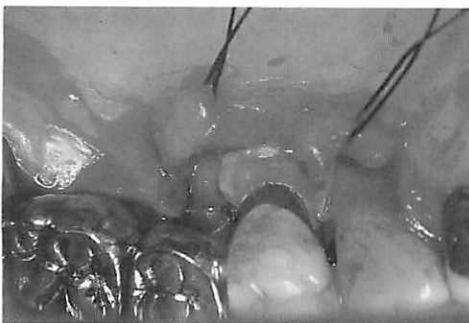


図30 遮断膜を設置した状態。

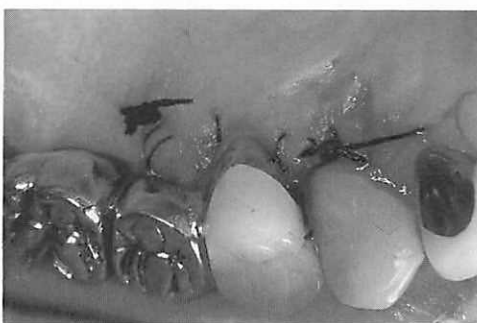


図31 歯肉弁を元の位置に戻し、遮断膜を覆った状態。



図32 2週後抜糸した状態。

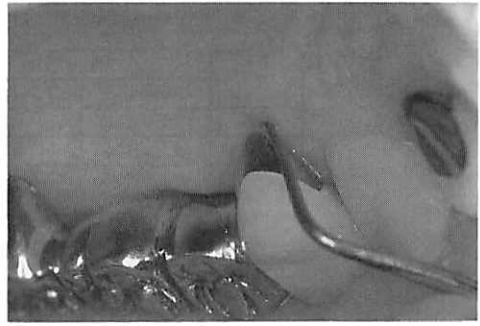


図33 7カ月目の状態。ポケットの深さは2mmに、アタッチメントロス3mmになっている。



図34 根分岐部に2度の病変があり、非吸収性膜を設置する前の状態。



図35 同部に非吸収膜を設置した状態。

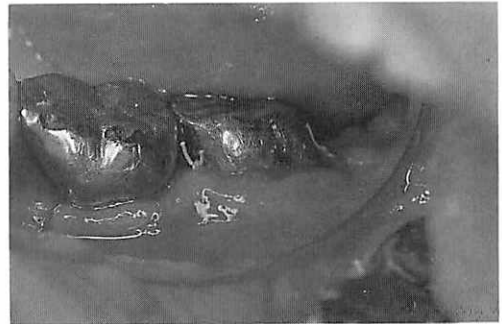


図36 歯肉弁を元の位置に戻し、遮断膜を覆った状態。

表2 根分岐部病変2度に対する非吸収性膜を用いたGTR法の効果。

	頬側分岐部		舌側分岐部	
	実験部位	コントロール部位	実験部位	コントロール部位
術前	7.3±1.1	7.3±1.5	7.5±1.6	7.2±0.6
6か月後	3.2±1.4	5.8±1.1	4.6±1.7	6.6±0.7

数値はアタッチメントレベルをmmで表わしている。実験側はGTR法を行った部位。コントロール側は歯肉剝離掻爬術を行った部位。GTR法を行った部位で有意にアタッチメントゲインが見られる。

表3 GTR法における非吸収性膜と吸収性膜との比較。

	Polyglactin 910	ePTFE
術前	8.20±1.27	7.80±1.55
12か月後	5.10±1.67	4.95±1.66
24か月後	4.75±1.60	5.85±2.83

数値はアタッチメントレベルをmmで表わしている。GTR法の適応症を実験対象とした。Polyglactin 910は吸収性膜の1種類、ePTFEは非吸収性膜。両者の間には差は見られなかった。

表4 GTR法における吸収性膜間の比較。

Polylactic acid		Polyglactin-910	
術前	12か月後	術前	12か月後
9.2(±1.8)	6.0(±1.2)	8.7(±2.6)	6.0(±1.9)

数値はアタッチメントレベルをmmで表わしている。2壁性および3壁性垂直性骨欠損を対象にGTR法を行った。使用した吸収性膜の間に差はなかった。

場合がある。1つは人工歯根を歯槽骨内に埋入する前に、歯槽堤の骨増生を計る場合である。主に歯槽骨の欠損が大きい場合に適応される。粘膜弁を形成した後、骨欠損部に骨移植を行い、移植骨の上を遮断膜で覆う。必要があれば遮断膜をピンで固定する。粘膜弁を元に戻す。人工歯根埋入時に行われることもある上顎洞底増大術(maxillary sinus floor augmentation procedure)でも同様な方法が用いられる。もう1つの方法は人工歯根を埋入した後、骨が不足している部分に骨の増殖をさせるための方法である。粘膜弁形成後、人工歯根を埋入し、人工歯根が露出している部分を遮断膜で覆う。その部位に骨ができるスペースを確保するために骨移植を行ったり、チタン補強をした遮断膜を使用することがある。必要があれば遮断膜をピンで固定する。粘膜弁を元に戻す。

## 5) 臨床成績

術式のところで述べた適応症に従ってGTR法を行った場合、その成績は良好である。遮断膜として始めに開発されたのが非吸収性膜であり、その臨床成績は1988年以降多く報告されている(表2)。非吸収性膜が使用されるようになった後、2次手術を避ける目的で吸収性膜が開発され、使用されるようになった。非吸収性膜を使用した場合と吸収性膜を使用した場合の臨床成績には差はないという報告が多く出された(表3)。更に多くの種類の吸収性膜が市販されるようになり、その臨床成績は検討されているが、種類により差があったという報告はないようである(表4)。非吸収性膜を使用した時のX線写真を図37-40に示す。吸収性膜を使用した時のX線写真を図41-44に示す。



図37 上顎右側第1小臼歯近心に2壁性の骨欠損が見られる。GTR法術直前の状態。



図38 非吸収性膜を使用した14カ月後の状態。骨欠損のあった部位に骨の再生が見られる。

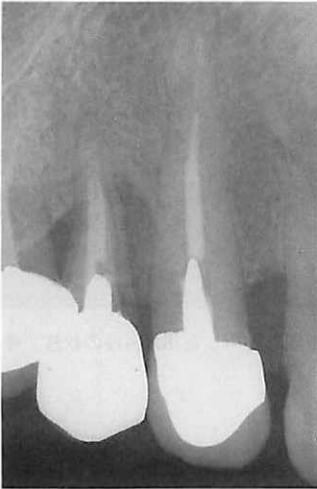


図39 上顎左側第2小臼歯口蓋側にカップ状骨欠損が見られる。GTR法術直前の状態。



図40 非吸収性膜を使用した12カ月後の状態。骨欠損のあった部位に骨の再生が見られる。

## 6) まとめ

現在歯科領域で行われている GTR 法について述べた。歯科領域においては遮断膜を用いる方法が採用されているが、今後膜の改良が行われると思われる。現在エナメル蛋白のある種のものを歯面に塗布する

GTR 法が考案されているが、まだ臨床成績が不足していて、評価が定まっていない。今後成績いかなんではこの方法が主流を占める可能性がある。また種々の成長因子を用いる方法などが可能になってくとも考えられる。

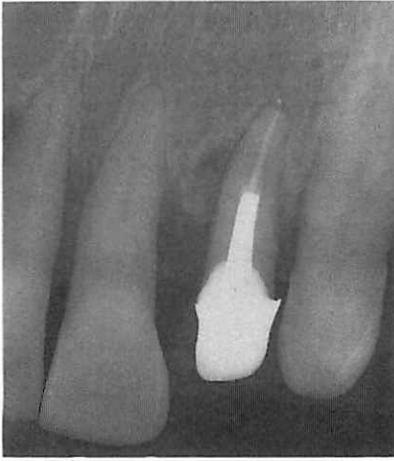


図41 上顎左側第2側切歯口蓋側から近心にかけて3壁性の骨欠損が見られる。GTR 法術直前の状態。



図42 吸収性膜を使用した14カ月後の状態。骨欠損のあった部位に骨の再生が見られる。

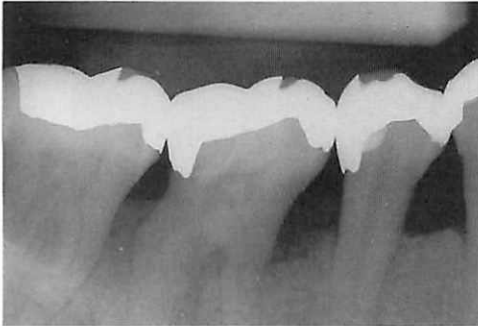


図43 下顎左側第1大臼歯根分岐部に2度の病変が見られる。GTR 法術直前の状態。

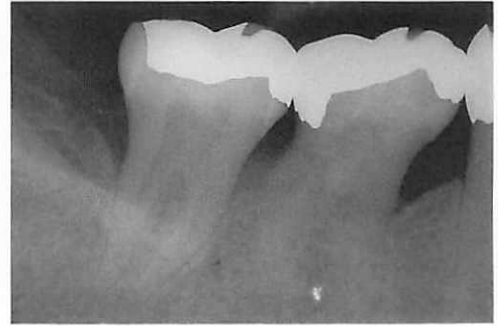


図44 吸収性膜を使用した18カ月後の状態。骨の再生が見られる。

#### 参考文献

- 1) 中村社網, 浦口良治, “GTRの科学と臨床”, クインテッセンス出版, (1993)
- 2) 末田 武, 岡本 浩, “GTR法の臨床”, 日本歯科評論, (1993)
- 3) 中村社網, 末田 武, 井上 孝, 小宮山彌太郎訳, “GBRの歯科インプラントへの応用”, クインテッセンス出版, (1995)
- 4) 小野善弘, 中村公雄監訳, “インプラントセラピー”, クインテッセンス出版, (1998)
- 5) J. Caton, S. Nyman, H. Zander, “Histometric evaluation of periodontal surgery II. Connective tissue attachment levels after four regenerative procedures”, J. Clin. Periodontol., 7, 224-231, (1980)
- 6) A. H. Melcher, “On the repair potential of periodontal tissues”, J. Periodontol., 47, 256-260, (1976)
- 7) S. Nyman, J. Lindhe, T. Karring, and H. Rylander, “New attachment following surgical treatment of human periodontal disease”, J. Clin. Periodontol., 9, 290-296 (1982)
- 8) R. Pontoriero, J. Lindhe, S. Nyman, T. Karring, E. Rosenberg and F. Sanavi,

- "Guided tissue regeneration in degree II furcation-involved mandibular molars. A clinical study", *J. Clin. Periodontol.*, 15, 247-254, (1988)
- 9) T. Kodama, M. Minabe, T. Hori and Y. Watanabe, "The effect of various concentration of collagen barrier on periodontal wound healing", *J. Periodontol.*, 60, 205-210 (1998)
- 10) A. Linde, C. Thoren, C. Dahlin and E. Sandberg, "Creation of new bone by an osteopromotive membrane technique: An Experimental study in rats", *J. Oral Maxillofac. Surg.*, 51, 890-897 (1993)
- 11) P. Cortellini, G. Pini Prato and M. S. Tonetti, "Periodontal regeneration of human intrabony defects. II. Re-entry procedures and bone measures", *J. Periodontol.*, 64, 261-268 (1993)
- 12) R. G. Caffesse, C. E. Nasjleti, E. C. Morrison and R. Sanchez, "Guided tissue regeneration comparison of absorbable and nonabsorbable membrane in dogs", *J. Periodontol.*, 65, 583-591 (1995)
- 13) W. Becker, B. E. Becker, J. Mellonig, R. G. Caffesse, K. Warrar, J. G. Caton and T. Reid, "A prospective multi-center study evaluating periodontal regeneration for class II furcation invasions and intrabony defects after treatment with a bioabsorbable barrier membrane: 1-year results", *J. Periodontol.*, 67, 641-649 (1996)
- 14) D. Huttmacher, M. B. Hurzeler, H. Schliephake, "A review of material properties of biodegradable and bioresorbable polymers and devices for GTR and GBR applications", *J. Oral Maxillofac. Implants*, 11, 667-678 (1996)
- 15) K. Kubo, N. Tsukasa, K. Iki, M. Uehara, A. Shimotsu, Y. Seto, S.-H. Hyon, Y. Ikada, T. Kubota and T. Sueda, "Occlusive effects of lactic acid-glycolic acid copolymer membrane on gingival fibroblasts in vitro", *J. Biomed. Mater. Res.*, 39, 554-559 (1998)
- 16) M. Christgau, N. Bader, G. Schmalz, K.-A. Hiller, A. Wenzel, "GTR therapy of intrabony defects using 2 different bioresorbable membranes; 12-month results", *J. Clin. Periodontol.*, 25, 499-509 (1998)
- 17) P. Eickholz, T.-S. Kim, R. Holle, "Regenerative periodontal surgery with non-resorbable and biodegradable barriers: results after 24 months", *J. Clin. Periodontol.*, 25, 666-676 (1998)
- 18) L. Laurell, J. Gottlow, "Guided tissue regeneration update", *International Dental J.*, 48, 386-398 (1998)

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# 明治初期の系統解剖学書

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## I. はじめに

我が国の学問は幕末期から明治初期にかけてはオランダからの輸入による蘭学に始まりその後わずかの時期に、米・英・独・仏からの学問が輸入されることにより外国からの知識が入り乱れた時期となった。解剖学においても他の学問と同様の状態であった。このような混沌とした時期、即ち明治初期の解剖学書についての詳細な書誌学的な報告はこれまであまりなされていない。その理由としては明治初期からこのかた百年以上経過しているために書物が完全な状態で現存しているものが少ない。また現存していても多くは貴重本になり容易なる閲覧も出来ないのが現状である。

そこで今回私蔵する明治初期のいくつかの解剖書についてそれらの記載内容などを紹介して現在の解剖書に至るまでの経過の一端を考察してみることとする。

## II. 解剖書紹介

宝暦4年(1754年)2月7日、京都西郊の刑場にて処刑された嘉右衛門(俗に屈嘉)の屍体が当時の京都所司代酒井忠則の許可のもとに山脇東洋、同志門人達により解剖観察され、宝暦8年(1758年)12月には「蔵志」<sup>1)</sup> 乾坤二巻として発刊された。(図1) この書物は観察という事実にもとづく日本の初めての科学的な形の書物であることは意義が深い。

その後、明和8年(1771年)3月4日に江戸千住小塚原の刑場で老婆の腑分観察を行った前野良沢、杉田玄白、中河淳庵らの蘭医によりオランダ語解剖書 Johan Kulmus の Tabula Anatomica (1731年)がその後4年の歳月を経て翻訳され完成される。この書

こそが「解體新書」<sup>2)</sup>として後生にまで残る近代日本医学の原点ともなる書物となる。「蔵志」、「解體新書」などの実際の解剖体の観察により西洋の解剖学の記載や図のすばらしさを認識されたのは幕末から明治の初期の頃であり、この時期よりこれまでの中国系の医学から西洋医学へと日本の解剖学はすさまじい変化をきたすようになる。この様な混沌とした時期を医学史研

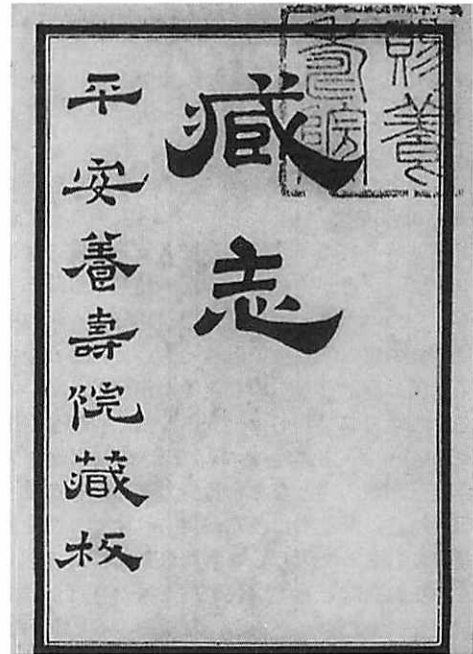


図1 山脇東洋の「蔵志」



図2 解體新書の表紙

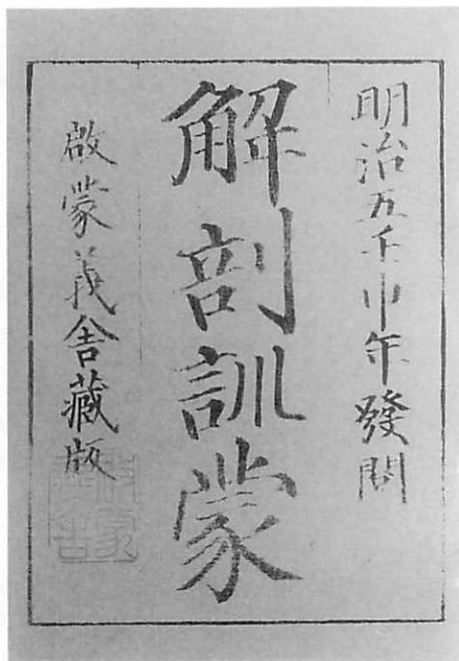


図3 解剖訓蒙の表紙

究家である阿知波<sup>3)</sup>は大きく四つの時期に分類している。彼によるとこれらの時期とは

- 1) ドイツ解剖書の蘭訳書を輸入していた時期 (1840年以降)
- 2) 直接ドイツ解剖書を輸入し、原著と先に輸入したその蘭訳書とを比較しつつドイツ医学を受容した時期 (1850年～1870年頃)
- 3) 英・米からの解剖書がいちどに入ってきた時期 (1865～1880年頃)
- 4) ドイツ解剖書の優秀性が認識されわが国の医学界にドイツ医学書が定着した時期 (1887年以降)

である。この中でもとくに第3期 (1865年から1880年頃) に今日の解剖学教書の原点ともいえるような多くの英・米国の解剖書からの翻訳書が出版されている。そして、これらの書物名は現在の解剖教科書<sup>4)</sup>や医学史<sup>8,9)</sup>の中でもよく出典されているが実際それらの書物の詳述な記載内容となると皆無である。そこで今回は、明治時代に医学生に多く使用されすでに歴史的な書物になってしまったこれらの解剖教書について紹介していく。なお当時としては代表的な解剖書ばかりではあるが紹介にかたよりのあることをおゆるし願いたい。

#### ① 解剖訓蒙 (図3)

本書は明治5年 (1872) 3月から明治9年 (1876)

1月にわたり啓蒙義舎蔵版より全20巻揃いで出版された。当時の価格にして3圓2分10朱で大阪の佐々木吉良、浅井吉兵衛、松村九兵衛らの書店を通じて販売された書物である。大阪の松村矩明 (当時文部少教授) を中心とした安藤正胤、副島之純、村治重厚、横井信之、中泉正らの6名により米國ペンシルバニア大学の Joseph Leidy による原著名「An Elementary Treatise on Human Anatomy」の部分翻訳である。本書は袋綴本で表紙はブルー色、四針眼、用箋は楮紙の形式をとり大きさは縦225×横152mmである。なおこの書物の内容については第1巻の目録箇所を見てみると、第一篇 骨論、第二篇 関節靱帯論、第三篇 筋論、第四篇 栄養器論 (口腔、咽頭、胃管、胃、腸、膵、肝、脾)、第五篇 脈管論 (心臓、動脈、静脈、水脈)、第六篇 呼吸器論 (咽頭、気管、肺臓、付属腺)、第七篇 泌尿器論 (腎臓、副腎、膀胱、尿道)、第八篇 生殖器論 (睾丸、陰茎、精囊、付属腺、子宮、卵巣、膣、外陰部、乳房)、第九篇 神経論 (脳、脊髓、神経)、第十篇 五官論 (視官、臭官、聴官、味官、觸官)、第十一篇 組織論 (骨、軟骨、筋、神経、諸膜、諸腺、歯牙等ノ組織及ヒ纖維、弾力性、纖維軟骨、脂肪等ノ組織) の十一篇系より本書は構成されている。さらなる詳細は島田<sup>5)</sup>がすでに報告している。

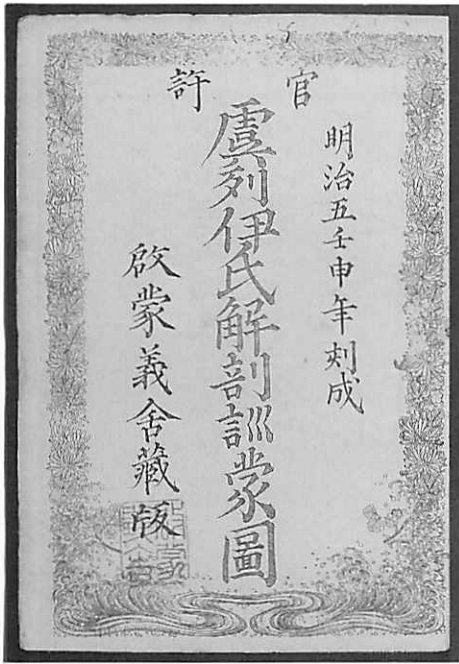


図4 眞列伊氏解剖訓蒙図の表紙



図5 解剖摘要の表紙

② 眞列伊氏解剖訓蒙図 (図4)

本書は Henry Gray (1828~1861) の著書による「Anatomy, Descriptive and Surgical」Philadelphia. Blanchard and Lea 出版 (1862) の各部位の図とその用語とを翻訳してまとめた図譜書であり全2巻より構成されている啓蒙義舎蔵版弘所より明治5年 (1872) に出版された。

第1巻は頭部の骨図より始まり下腿筋まで全45ページより構成されている。第2巻は46ページの縦断鼻腔口内咽頭図より始まり、脈管系、呼吸器系、泌尿生殖器系、神経系、感覚器系へとすすみ全99ページの図にて終了する左右両開きの図譜書であり、大阪の松村九兵衛により発売されているが当時の価格については記載がなく不明である。なお Original の本書の装丁については今日は前所有者が再装丁しているために述べる事ができない。

③ 解剖摘要 (図5)

本書は明治8年 (1875) 10月23日板権免許を得て同9年 (1876) 6月2日出版され、当時の価格は1円50銭であった。本書は米国ペンシルバニア大学のニールとスミスの解剖書 (1869年版) の部分翻訳とされている。石川縣下土旗の松村矩明が譯者となり大阪の高木玄真が編撰出版人となり出版された。本書は全7巻より

構成され、その装丁は袋綴本で表紙はブルー色、四針眼、用箋は楮紙で、大きさは縦220mm×横152mmである。内容は第1巻 (骨論上) は脊椎骨より始まり下顎骨まで各骨の骨学概論を全29ページわたり述べられている。第2巻 (骨論下) は 頭部の骨についての総論より始まり上肢、前腕、指骨、下肢、下腿骨、足骨について述べている。この構成には全26ページが当てられている。第3巻 (靭帯論 筋論上) は関節論即靭帯より始まり足の靭帯論について述べさらに歯牙、表皮、毛髪、皮脂腺など消化器器官の一部と感覚器および頭頸部以外の筋について足の部位に至るまで全34ページにわたり述べられている。第5巻 (消化器篇) は内臓、消化器に始まり腎臓、膀胱などの泌尿生殖器系について全43ページにわたり述べられている。第6巻 (呼吸器及血管篇) は呼吸及血運器についてとくに今日での胸部内臓器官が記されていると同時に静脈系についても記されており全43ページにわたっている。最後の第7巻 (神経系統編, 五官論) は中枢神経と末梢神経及び現在の感覚器器官についての記述であり全44ページにわたっている。

なお本書の中には図は記されていないため同時に解剖摘要図完 (図6) を敬虔堂蔵版にて出版されている。本書は全55ページより構成された左右両開きの図譜で



図6 解剖摘要図完の表紙

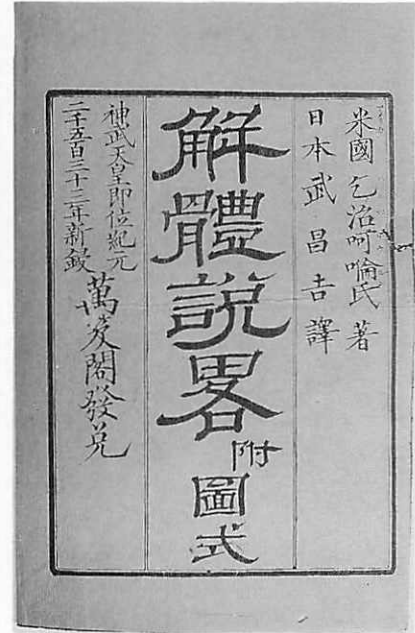


図7 解體説略の表紙

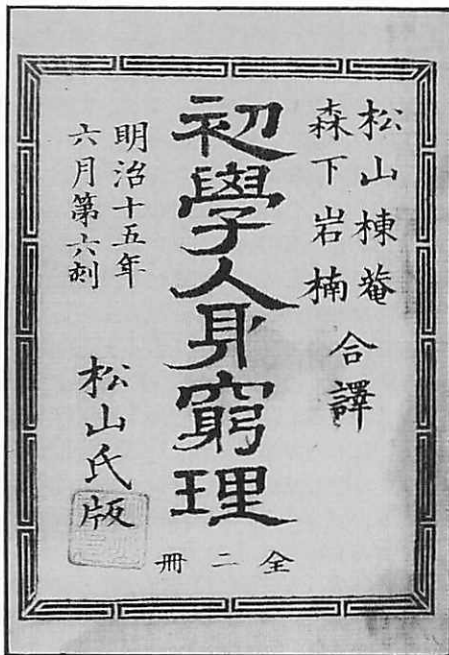


図8 初学人体窮理の表紙

④ 解體説略 (図7)

本書は米国のHenry Hartshorne「A Conspectus of the Medical Science」シリーズ7冊の中の一部からの翻訳であり明治6年(1873)に萬笈閣發兌にて出版された全巻3冊本であり、当時の価格は87銭5厘であった。その3冊のうちわけは巻1, 2は本文内容説明であり、第3巻は図譜のみから構成されている。袋綴本で表紙はブラック色、四針眼、用紙は楮紙で、大きさは縦225mm×横152mmである。その内容は第1巻は骨学総論に始まり骨組織、脊椎、頭骨、顔面骨及び頭部についての総論から舌骨までを全27ページにまとめている。第2巻は胸郭、骨盤、上肢骨、下肢骨、歯牙、関節論及び各部の関節説明が全39ページにわたり述べられている。第3巻はこの第1, 2巻で説明された箇所の図の説明にあたっており「解體説略図式, 1, 2」というタイトルになっており、その内容としては全身骨格図に始まり全部で36図からなっている。この書は骨および筋についての記載のみで消化器、循環器、神経系についての記載はいっさいなされていない。たぶんシリーズの中で全体の部分の翻訳がされずに終了してしまったものと思える。

⑤ 初学人身窮理 (図8)

明治6年(1873)3月に慶應義塾の松山棟庵、森下

真列伊氏解剖訓蒙図に似た形式である。

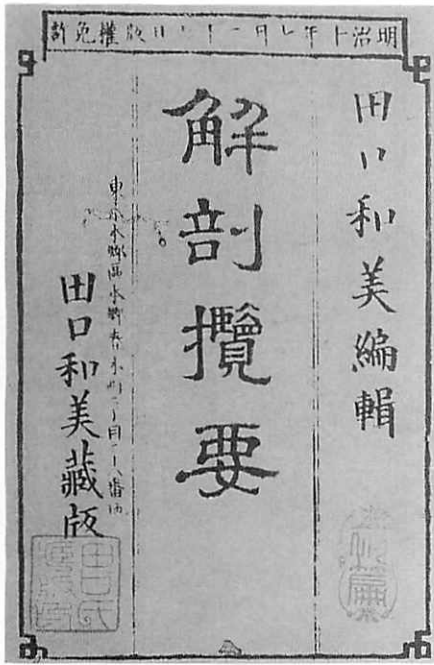


図9 解剖攬要の表紙



図10 華氏解剖摘要圖の表紙

岩楠により米国のカットの書の一部を翻訳し、慶應義塾出版社より発行された書である。本書は人体解剖の概略とそれら器官の生理作用について一般向けにやさしく述べられた書物で全2巻より構成されている。内容的な記載からみて、この書物は医学生向きではなく一般の人々を対象とした人体を知るうえでの啓蒙書である。上巻は骨、肉、歯、消化、循環、リンパ系、分泌、栄養、呼吸、体温についてこれらのことについてやさしく述べられている。下巻には音の出る器官、皮膚、神経、五官（感覚器）、健康法、病気にならないため、看護人の心得などが記されている。上巻55ページ、下巻40ページより構成され、下巻の最後には全身骨格図が1ページ付加されている。本は袋綴本で表紙はバイオレット色、四針眼、用紙は楮紙で大きさは縦223mm×横148mmである。

⑥ 解剖攬要 (図9)

本書は今日の解剖学会の初代会頭であり東京大学医学部解剖学教室の初代教授（明治9年6月）でもあった田口和美が独英の解剖書を参考にしつつ書かれた日本人による初の解剖書であり全13巻14冊よりなり全1042ページにのぼる膨大な書物である。

本書は田口和美蔵版にて明治10年（1877）7月26日版權免許をとり明治14年（1881）7月10日出版されて

いて、陸軍本病院、海軍本病院、東京大学医学部、東京府病院等から官版御用所の許可を得た書物である。内容は第1巻は骨学特に軀幹骨としての脊椎、胸骨、肋骨、胸郭、舌骨などについて記されている。第2巻は頭骨、頭蓋骨、顔面骨、鼻腔、眼窠、口腔、頭顱窩、蝴蝶頸骨窩、翼状口蓋窩についてである。第3巻は四肢骨、下肢骨、骨盤、足骨について、第4巻は靭帯頸であり幹靭帯、四肢靭帯（上肢、下肢）についての詳述である。第5巻は筋学であり第一章として軀幹筋であり背筋、腹筋、胸筋、頸筋及頭筋、頭筋膜についての記述である。第6巻は第二章として四肢筋についてでありこれをさらに上肢筋、下肢筋にわけて述べている。第7巻は第四篇内臓学であり第一章は消食器（消化器）、第二章は呼吸器について各器官の説明が記されている。第8巻は第三章として溺器（現在の泌尿器系）について述べられ、第四章は男女の生殖器系について、第五章は血管腺（現在の内分泌器官）について記されている。第9巻は第六章として五器官（感覚器）についてでありまず、觸器（皮膚器官）、視器（視器）、聴器、嗅器、味器について述べられている。第10巻は第五篇脈管学であり、第一章に心臓、第二章に動脈、胸部大動脈幹の枝について述べられている。第11巻は動脈の腹部大動脈幹に始まり、第三章は静脈、第四章



図11 海都満氏原図山崎元脩模寫解剖圖の表紙



図12 海朱満人解剖書の表紙

は淋巴管について詳述している。第12巻は第六篇神経學で第一章は脳脊髄，神経系統／中樞部について脊髄，脳髄，脊髄及脳髄被膜について述べられている。第13巻上は第二章脳脊髄神経系統の末梢部，12対の脳髄神経についての記載である。最後の13巻下は脊髄神経と第三章の交感神経系統についての記載である。本書の以前の書物との大きな違いとしては解剖用語にはすべてラテン名が加えられたことである。本書の装丁は縦185mm×横125mm厚さ（全13巻14冊）にて，袋綴本で表紙はブルー色，四針眼で用箋は楮紙よりなっている。

⑦ 華氏解剖摘要図（図10）

本書はH. Hartshorneの「A Conceptus of Medical Sciences」（1824年版）の翻訳書で華氏解剖摘要の図譜として明治10年（1877）4月17日版權免許を取得後同年10月30日に村上典表により翻訳され大阪の松邨九兵衛により出版された縦187mm×横123mm，総82ページよりなる洋装版で二百二十八図が画かれているコンパクトな解剖図譜である。

⑧ 海都満氏原図，山崎元脩模寫解剖圖（図11）

本書は明治13年（1880年）3月から明治17年（1884年）7月にわたり吐鳳堂書店，英蘭堂書店より發賣された日本人による最初の模写の解剖図である。洋装装丁本で全502ページよりなっている。本図譜のKarl

Heitzmanの「Die descriptive und topographische Anatomie des Menschen」2 Bde. 1870 Wienである。

本書の図は原著の中からの図を模写されたものであるが残念ながら原著の図とともに記載されている説明については本書には記載がない。

⑨ 海朱満人解剖書（図12）

本書は当時東京大學解剖学教室の助教授であった今田東が校閲し，鈴木規矩治，磯鼻，浅田決，黒柳精一郎の四名により翻訳された図譜であり，山崎が模写した海都満氏解剖図と同じKarl Heitzmanの書である。明治15年（1882年）5月4日版權免許を取得，明治20年（1887年）7月金原寅作藏版にて發行された洋装装丁の260ページ600図からなる図譜書であるが前述の書との大きな違いはオリジナルの図についている説明文についても訳されて，より図が理解されやすいようになっていて原著に近い翻訳書になっていることである。

Ⅲ. おわりに

書誌学的に明治の解剖学書を見てみると明治の初期頃には蘭学書からいっきに英米書の解剖書の輸入となり翻訳書のほとんどが英独書の解剖書の翻訳にとっかわっている。この中でもとくに英語圏の解剖書では

現在も多く使用されている Gray's Anatomy があげられる。当時米国の医学の中心であったフィラデルフィアを中心に出版された英語の医学書がこの当時解剖学以外でも多く翻訳されたことは注目にあたいすることである。

一方明治4年(1871年)から東京大學を中心にドイツからのおかかえ教師の来日によりドイツ医学の定着へと進んでいく中で明治10年前後は英語系の医学が、ドイツ系と同時に輸入されて一時期は混沌とした。その時に今回紹介した様な解剖書がぞくぞくと出版されているがその後、東京を中心とした医学はドイツ語系に定着されてくるにしたがって解剖書はすべてドイツ系のスタイルへとかわっていく。そのはしりとなるのが田口が著した「解剖攬要」であり、また図譜では「海朱満人体解剖」である。その後現在にいたるまで解剖書はドイツ系の様式にそった分冊スタイルの教科書<sup>9)</sup>が主流となり今日に至っている。

#### 謝辞

稿を終るにあたり原稿のワープロ打ち込み、整理ならびに写真作成などの作業をしていただいた口腔解剖第二講座の事務和田フミ子、技官福重和人の両氏にお礼申し上げます。

#### 参考文献

- 1) 山脇東洋：復刻版「蔵志」. 医学古典刊行会, 大阪, 1968
- 2) 杉田玄白, 中川淳庵, 石川玄常, 桂川甫周：復刻版「解體新書」. 講談社, 東京, 1973
- 3) 阿知波五郎：幕末明治初期(1840-1887)解剖学書(内, 外)目録について—とくに19世紀欧米解剖学書目録とその蘭訳書と和訳書との関係—, 日本医史学雑誌, 22, 215-236, 1976
- 4) 阿知波五郎：近代日本の医学—西洋医学受容の軌跡 Ⅲ. 解剖学書誌からみた幕末明治初期の混沌期, 358-382, 思文閣出版, 京都, 1982
- 5) 島田和幸：明治初期の系統解剖学書 1. 【解剖訓蒙】について, 形態科学, 2, 5-8, 1997
- 6) 松山陸郎：第五編 先生の記事と演説, 97-134, 松山病院, 東京, 1943
- 7) 東京大学医学部創立百年記念会：東京大学医学部百年史, 333-340, 東京大学出版, 東京, 1967
- 8) 小川鼎三：日本医学の発達, 解剖学発達の回顧, 成田武二編, 13-31, 日新医学社, 東京, 1956
- 9) 金子丑之助：日本人体解剖学, 第1巻, 14, 南山堂, 東京, 1968





# 免疫系の抗原認識と特異性

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## Antigen Recognition and the Specificity of Immune System

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### Abstract

Both innate and acquired immunity are indispensable for human beings to survive. Acquired immunity is mediated by lymphocytes that possess antigen receptors on their cell surfaces, and are roughly divided into two populations, T cells and B cells. Although their biological roles are distinct, the structures of ligand binding sites of the receptors share characteristics in a great extent. One binding site comprises heterodimeric protein subunits, and 6 discontinuous sites in the protein primary structures, termed complementarity determining regions, take part in making it up. Therefore, the tertiary and quaternary structures of the receptor proteins play critical roles for the antigen-binding capacity. Structural and functional complementarity between the surfaces of receptor and antigen is required for the specific binding. In response to a protein antigen, T cells recognize oligopeptidic fragments of the protein bound to the self-major histocompatibility complex (MHC) class II molecules. The peptide-MHC complex is provided by antigen-presenting cells (APC), including several different types of cells. Thus, T cells can not react to any structures of the protein itself, whereas B cells can recognize surface structures of the protein. A harmonized collaboration among the three types of cells is required for the progression of humoral immune response. Finally, importance of higher order structures of proteins for the B cell epitopes is discussed, as to the immunodominancy.

## I. はじめに

生物は生存のために、種々の病原微生物の侵襲から身体を守らなくてはならない。広い意味での免疫 (immunity) とは、その生体防御機構全体のことを指す。これには、好中球を主体とする種々の食細胞はもちろん、上皮の角化層や粘膜上皮を被う分泌液などのバリア機構まで含めることができる。一方、古く紀元前のギリシャ時代以来人々は、ある特定の伝染性疾患から回復した人は再び同一の疾患にかからないという事実に気付いていた。このような“(抗原) 特異性”と“記憶”を伴う免疫現象が、狭義の免疫である。すなわち、広義の免疫は、“特異性”と“記憶”を伴わないもの (innate immunity) と、両者を随伴することを特徴とするもの (acquired immunity) に大別される。Acquired immunity を初めて人為的に制御し医療に実用化したのが、有名なジェンナーの種痘であり、今から200年前の事であった。パスツールやコッホらによって病原微生物の概念が成立する約100年も前の事である。

今世紀に入ってから、免疫学は飛躍的に進展した。特にこの20~30年は目覚ましいものがある。これには、分子生物学的、遺伝子工学的技術の急速な進歩に依るところが大であるのだが、また免疫学の方からも、生命科学全体の進路を切り開くような大発見がいくつもなされてきた。利根川進の見出した体細胞における遺伝子再編現象<sup>1)</sup>や、Köhler と Milstein のモノクローナル抗体の作製<sup>2)</sup>などは、各々過去の常識を覆し、あるいは長い論争に終止符をうち、さらにその後の生命科学全般において研究方法論を完全に変えてしまう影響力を示した。

さて、学問領域としての免疫学には、innate immunity と acquired immunity の両者が含まれるので、免疫学者によっても、“免疫”という言葉は各人の専門とする亜領域の違いによって、かなり大きなニュアンスの違いをもって受けとめられているようである。元来“immunity”とは伝染病の“2度無し現象”を表現した言葉であり、生体防御機構そのものではない。一般の人々が免疫という言葉からイメージするのも、やはり主として acquired immunity であるように思われる。本稿で以下に述べる内容も、acquired immunity についてであり、これが示す“特異性”と“記憶”という2大特徴のうち、前者を規定する分子認識のメカニズムについて、現在までにはほぼ理解の固まったと思われる点を整理してみたい。

## II. Acquired immunity の担当細胞=リンパ球

記憶と特異性を伴う免疫現象を司る主役の細胞はリンパ球である。生物は全て、何らかの生体防御機構を持つことで種の保存を可能にしているわけであるが、狭義の免疫機構を持つのはリンパ球を保有するもの、すなわち脊椎動物以上の高等生物のみである。リンパ球はT細胞とB細胞に大別される。光学顕微鏡レベルの形態的特徴や、両者ともに細胞表面に抗原物質を特異的に認識するための受容体分子を表現しているという類似性を有しつつ、細胞生物学的意義をはじめ種々の点で大きな違いがある。

## III. B細胞抗原受容体の分子構造

B細胞表面に存在する抗原受容体と、血中等に存在する抗体とは物質的にはほぼ同一である。休止期成熟B細胞は抗原物質その他から必要な刺激を受けると活性化され、分裂増殖し、形質細胞に最終分化して、可溶性の抗体、即ち免疫グロブリン (Ig: immunoglobulin) を体液中に産生する。これは、膜結合領域を欠いたB細胞抗原受容体そのものである。代表的なIgであるIgGの構造は、分子量約5万のH (heavy) 鎖と分子量約2.5万のL (light) 鎖とがS-S共有結合したヘテロダイマーが更にホモダイマーを構成する、すなわちヘテロダイマーのホモダイマーが1つの分子単位となっている (図1左)。

抗原結合領域はH鎖とL鎖両者のN末の領域が1つになって構成される。この領域は、一個体内においても抗体ごと、B細胞クローンごとで異なることからV (variable) 領域と呼ばれる。一方、これよりC末側の各ドメインは比較的变化に乏しくC (constant) 領域と呼ばれる。H鎖のC領域の違いによってIgは種々のクラス、サブクラスに分類される。またクラスによってはIgG様の基本単位がさらに2量体 (IgA) や5量体 (IgM) を形成する。クラス、サブクラスの違いによって抗体の生理的機能も変わってくるが、本稿ではC領域の機能についてはこれ以上触れずに、抗原結合性を司るV領域に限って話を進めたい。

V領域の中にあっても特に変化の著しい部分がH鎖L鎖それぞれに3カ所ずつ、計6カ所、アミノ酸配列上では不連続な位置に存在し、超可変領域と称される。この部分が抗体の抗原特異性を決定していることから、相補性決定領域 (complementarity determining regions: CDR) とも称される (図1、図5も参照)。1次構造上では離れた位置に存在する6つのCDRが、正しく折り畳まれたタンパク質になった時には互いに

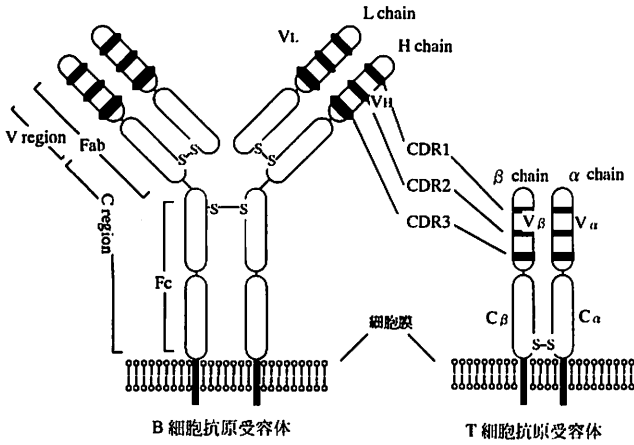


図1 リンパ球の抗原受容体の構造。B細胞抗原受容体(左)はIgG, IgD, IgAの場合を示す。IgM, IgEではC領域に4つめのドメインを有する。T細胞抗原受容体(右)にはγ鎖とδ鎖からなるタイプのものもあるが、本稿においては取り上げない。

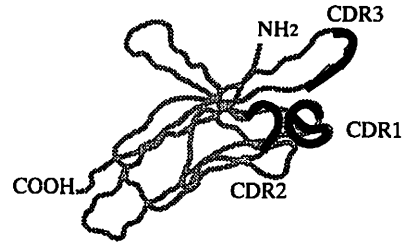


図2 免疫グロブリン(Ig)のV領域の3次構造。L鎖のV領域を例として示す。1次構造上は離れて位置する3つのCDR(図1および図5参照)は立体構造上は近接している(濃く示した部分)。H鎖においても同様に折り畳まれて全6カ所のCDRは互いに近接し1つの抗原結合面を構成する。

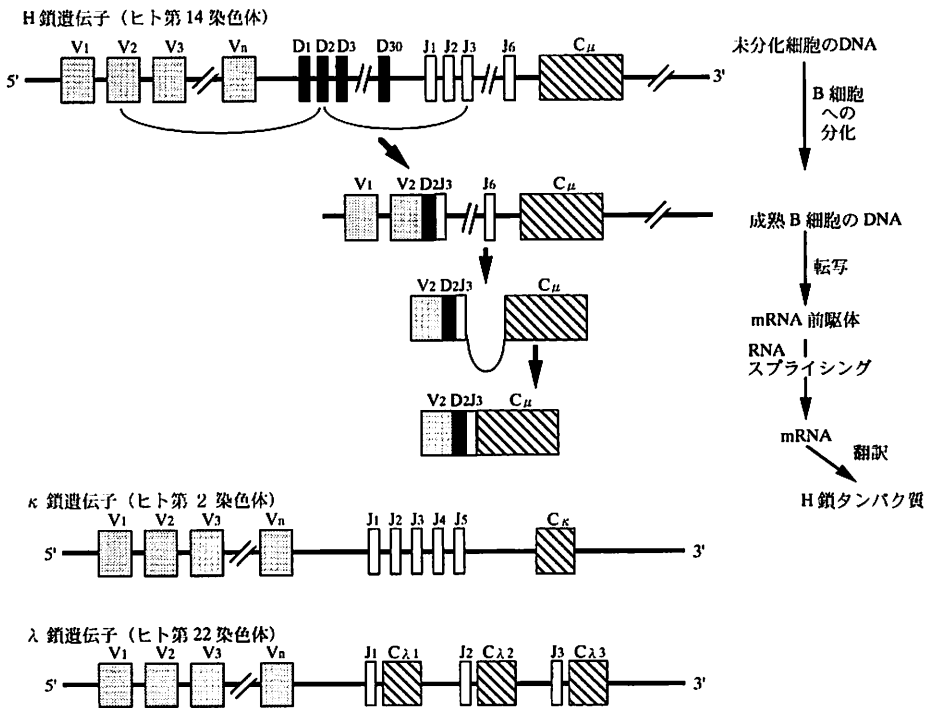


図3 抗体遺伝子の構造と遺伝子再編成

近傍に位置し、協調的に単一の機能(抗体の場合は抗原結合性)の発揮に寄与する(図2, 図4も参照)。別の言い方をすれば、抗体可変領域のどの部分のアミ

ノ酸配列によっても抗体の機能は代表されない。これは、タンパク質の機能にとっての高次構造の重要性を端的に示す好例の1つである。

#### IV. T細胞抗原受容体

T細胞抗原受容体は、Igとは全く別の遺伝子産物であるが、その分子構造はIgのFab部と酷似している(図1)。したがって、分子レベルの抗原認識機構も抗体の場合とほとんど同一であるが、細胞生物学的役割や機能は全く異なる。この点については、後ほど触れる。

#### V. 抗原受容体の多様性の生成

抗原受容体が認識するものは、抗原分子の全体ではなく、ある特定の部位の構造的特徴である。この構造部分を抗原決定基、あるいはエピトープと呼ぶ。基本的に1個のリンパ球はただ1種類の抗原受容体を表現し、したがって1種類の抗原にのみ(もっと正確には1種類のエピトープにのみ)に結合できる。このことは、多くの生化学者たちが特別な免疫学的知識を持たずともモノクローナル抗体を作製し研究に活用していることでもわかるように、現在では至極当然の事として受け入れられているが、かつては免疫学の重要な研究テーマであった。

さて、この世に何種類存在するのか見当の付けようもない数の抗原に対して、免疫系は実際に、莫大な数のクローンを用意している。B細胞を例にとるとその数は少なくとも1億以上といわれている。いうまでもなく抗体、すなわちIgはタンパク質であり、したがってその遺伝子がゲノムの中に保有されているはずだが、我々は1億種類もの遺伝子をゲノムの中に保有することはできない。現在進行中のヒトゲノムプロジェクトから、機能遺伝子の総数は約10万個に過ぎないと推定されている。では、どのようにしてこの莫大な数の機能遺伝子を免疫系は用意することができるのか?この疑問に明快に答えたのが、ノーベル賞の対象となった利根川進の一連の研究であった<sup>1)</sup>。図3に示すように、H鎖を例にとると、将来V領域を構成する遺伝子はゲノム内で100を越えるV<sub>H</sub>断片、約30のD断片、6のJ断片に別れて存在している。これがB細胞への分化・成熟に伴って、V、D、J各断片が1個ずつランダムに選択され、結合し、機能的V領域遺伝子が完成する。これを抗体遺伝子の再編成というが、この組合せによって100×30×6、即ち18,000種類以上の多様性が生み出される。さらに各断片間の連結点では、連結が不正確に行われるため、ゲノムにコードされていなかった塩基対が挿入されたりフレームシフトがおきたりする。これを考慮するとH鎖の多様性はさらに莫大なものとなる。もちろん停止コドンにコードするよ

うになってしまう場合もあるが、その際にもすぐさま相同染色体からの遺伝子を使用して再編成をやり直す。同様の事が、L鎖においても行われる。L鎖にはκ鎖とλ鎖の2種類があり、それぞれ独立したV断片群が存在する(図3)。H鎖とL鎖の組合せもまたランダムであり、この結果抗体のV領域の機能的多様性は無限に近いものになる。

分化した細胞の遺伝子が、生殖系列細胞の遺伝子とは非可逆的に変化してしまっているという遺伝子再編成(rearrangement)の事実は、当時までの生物学のドグマ:遺伝子是不変で調節遺伝子産物に発現が調節される、あるいは1酵素1遺伝子説などを完全に覆すものであったと聞く。利根川はλ鎖を材料にしていち早くこの“動く遺伝子”の現象を解明したが、少し遅れてκ鎖やH鎖でも同様の現象が検証されることによって、全ての生物学、生化学の教科書が書き改められることとなった。ところが現在に至って、体細胞クローン動物の成功は、改めて我々に認識の変更を迫る。

T細胞抗原受容体の遺伝子も後ほど同定され、それが抗体遺伝子とは無関係の物質であることが明らかにされた。しかし、その遺伝子の構造上の特徴やタンパク質分子構造はIg(抗体)と酷似していた。すなわち、T細胞抗原受容体のα鎖とβ鎖でも、また同様の遺伝子再編成が行われ、これによって莫大な数のT細胞レパトリーが形成される。

T細胞抗原受容体にはなく、抗体に特有の現象とされるが、成熟した休止期B細胞が抗原刺激で活性化され分裂増殖する際に、異常な高頻度でV遺伝子に突然変異を起こすことが知られている<sup>3)</sup>。この体細胞突然変異によって抗原への結合力がより高くなったクローンが抗原刺激をめぐる生存競争の中で選択され、さらに増殖を続けることで、生体内全体として見た場合の抗体の親和性が次第に高まるものと考えられている。高頻度の突然変異はCDR領域を中心に起き、それ以外の部分たとえばC領域では変異は起きない。この変異導入を制御する分子機構は多くが未解明のままである。

#### VI. 抗原抗体反応(抗体の抗原認識)

いくつかの抗体・抗原複合体において、そのX線結晶構造解析により結合様式が詳細に解析されている。中でもPoljakらのグループの卵白リゾチームをモデル抗原に使用した一連の研究<sup>4,5)</sup>は、抗体の分子認識機構、ひいてはタンパク質のタンパク質認識機構を理

解する上で重要な知見を提供してくれる。彼らの得た結論をごく簡単にまとめると、相互作用のためには、抗体の抗原結合部位の分子表面と抗原エピトープの分子表面の間に、立体構造上の相補性とアミノ酸側鎖の機能的相補性（陽性荷電アミノ酸に陰性荷電アミノ酸、疎水性アミノ酸に疎水性アミノ酸）の両者が必要である。抗体側あるいは抗原側のわずかなアミノ酸変異は、親和性に定量的な影響を与えつつも定性的な結合は許容する。また、表面構造が一定の条件を満たしてしまえば、1次構造が全く異なる無関係な物質であっても本来の抗原と同等、時にはそれ以上に強く結合できる場合もある。

古くから、抗体と抗原の関係は鍵穴と鍵の関係に例えられてきたが、かつて抗体の交叉反応性をどの程度認識しながらこの例えが語られていたのかを筆者は知らないが、特異性とは相反するとも感じるこの点までを含めて、まさしく鍵穴と鍵である。ただし、タンパク質相互作用における構造上の相補性は、金属製の鍵と鍵穴のように絶対的なものではない。タンパク質は

柔らかく可塑性があり、結合時の構造が、フリーな状態での構造と異なっている場合があることが報告されている<sup>10,11)</sup>。この現象を induced fit と呼ぶ。

X線結晶構造解析は現在の生命科学においてまさに花形役者であるが、その限界についても是非ここで触れさせて頂きたい。結晶構造で明らかになるのは、物質が結晶化した時に取ったある特定の静的形態であり、溶液中で機能している時の形態と異なる可能性が常に考えられるのである。すなわち静止画像である。人間の群れが、狭い部屋で体育座りしている様子を観察して「人間の手はすねにくっついて存在し、顔と膝の距離は約20cmである」と言ってしまう可能性を常々念頭に置きつつ結果を読む必要がある。構造解析のもう一方の花形である核磁気共鳴法（NMR）では、結晶化という最難関ステップが不要で、しかも溶液中の動的な構造が解析できる。しかし、分析試料の分子サイズが大きくなるとコストと手間が途方もなく大きくなり、タンパク質間相互作用の解析に広く利用される状況には至っていない。電子顕微鏡技術も長足の進歩を

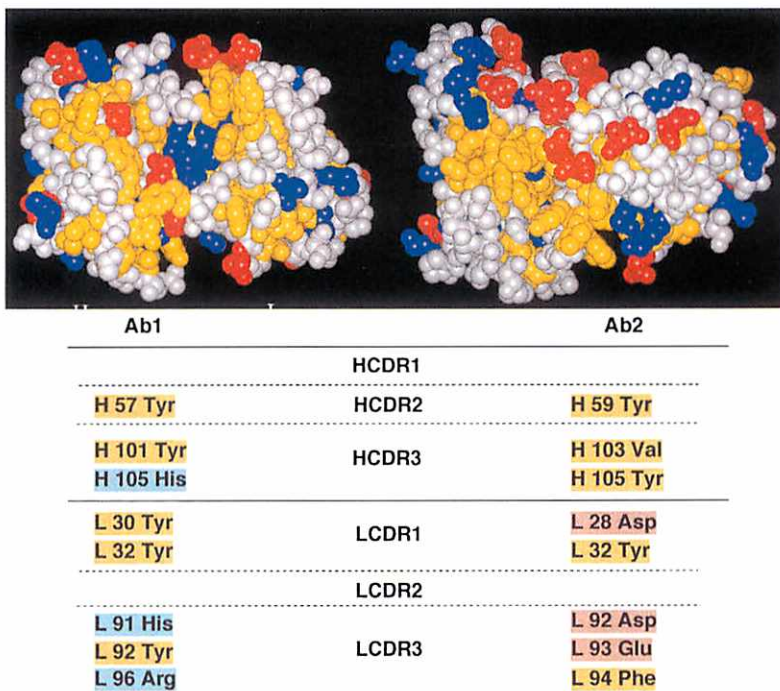
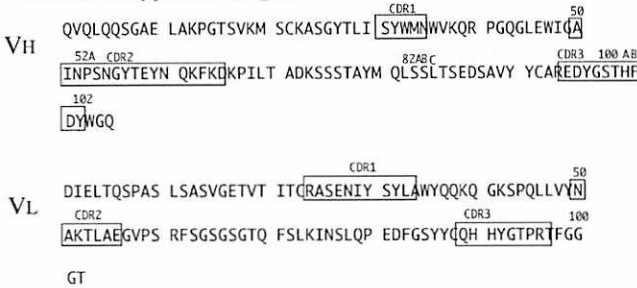


図4 抗II型コラーゲン抗体（Ab1）とAb1に対する抗イディオタイプ抗体（Ab2）の結合面の立体構造と相互作用に関与するアミノ酸残基の性質および由来。塩基性アミノ酸を青、酸性アミノ酸を赤、疎水性アミノ酸を黄の各色で表す。

## Ab1: anti-Type II Collagen



## Ab2: anti-I-5 Idiotope

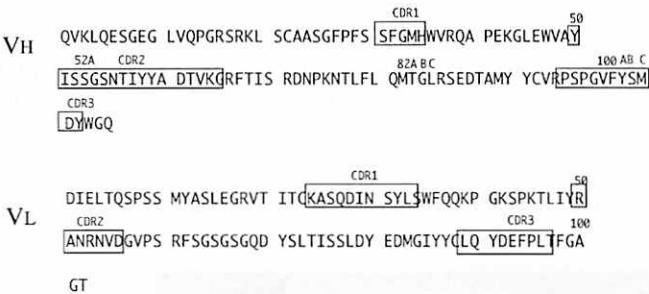


図5 抗Ⅱ型コラーゲン抗体 (Ab1) と Ab1 に対する抗イディオタイプ抗体 (Ab2) のV領域の1次構造, GenBank (NCBI sequence data base) accession number: U69538 (Ab1 V<sub>H</sub>), U69539 (Ab1 V<sub>L</sub>), U69540 (Ab2 V<sub>H</sub>), U69541 (Ab2 V<sub>L</sub>). ITO, H.-O. et al<sup>12)</sup>より改変。

遂げ、抗体分子ぐらいの大きさ (150kD) のものなら単一分子の姿を捉えることが可能となっているが、抗体抗原反応表面の原子間相互作用を観察するには程遠い。

さて、本稿では、抗原抗体反応の1例として、筆者らがコンピュータホモロジーモデリングによって解析したⅡ型コラーゲンに対するモノクローナル抗体とこの抗体に対するモノクローナル抗イディオタイプ抗体<sup>12)</sup>の抗原結合面の予想立体構造を紹介する (図4)。相互作用に関与すると考えられるアミノ酸残基とその1次構造 (図5) とを合わせて見て頂きたい。X線結晶構造は未確定のため詳細には不明な点が多く残されているが、塩基性アミノ酸 (Ab1) と酸性アミノ酸 (Ab2) による中央部の電気的相互作用を、周辺の芳香環側鎖を持つアミノ酸の疎水相互作用が補助する様子が見えてくる。形態的には凹面 (Ab1) と凸面 (Ab2) の相補性を示している。また、1次構造上は遠く離れて存在するアミノ酸残基が高次構造上で協調



図6 抗原ペプチドを結合したMHC class I 抗原。T細胞抗原受容体が結合する面を上方より見た様子。中央付近の黒い部分が抗原ペプチド。Class I 分子に結合できるのはアミノ酸6~8残基のもので、これより長いものは結合できず抗原となり得ない。Class II 分子の場合もほぼ同様であるが、アミノ酸残基数10~12あるいはそれ以上の長さのペプチドも結合が可能である。

的に上記の特徴を表現している点にも改めて注意していただきたい。抗体のH鎖とL鎖は独立したサブユニットであるので、このような高次構造を4次構造と称する。Ab1とAb2の2つのタンパク質間の親和性が両者の4次構造に完全に依存し、3次構造の保持では不十分であることは、免疫化学的にも確認されている<sup>12)</sup>。

## VII. T細胞の抗原認識機構と抗原提示

T細胞の抗原受容体の分子構造や遺伝子構造は、前述のように抗体と酷似しており、その分子レベルの認識機構も、抗体の抗原認識となんら異なるところはない。しかしながら、結合する相手に大きな制約がある。T細胞抗原受容体は自己の組織適合性抗原 (major histocompatibility complex antigen: MHC) に結合した、抗原タンパク質の断片を認識するのみであり、抗原分子の表面部分構造を認識する抗体とは性格を大きく異にする<sup>13,14)</sup>。自己MHCに反応しないT細胞は分化の初期段階で死滅し、自己に反応性を示すT細胞

だけが成熟して末梢組織に供給され機能する。このように言うと意外に感じられる人もいるかもしれないが、これをT細胞の正の選択 (positive selection) といひ、まぎれもない事実である<sup>15)</sup>。もちろん自己抗原に強く反応し過ぎる前駆細胞も分化の初期に除去されており、こちらを負の選択 (negative selection) と言ひ<sup>16)</sup>。さて、免疫系による自己と非自己の識別がいかに制御されているのかは、現在でも免疫学の中心中の中心的課題であり、簡単に説明は出来ない。また、本稿の主旨ともはずれるので、この点に興味をお持ちの方は多田富雄氏の名著<sup>16)</sup>があるのでご一読を願ひたい。

図6に示すように、MHC-抗原ペプチド複合体のT細胞抗原受容体との結合面の大部分は、自己由来であり、中央部分の限られた領域にごく短いオリゴペプチドが結合する。全体としての構造が、対応する成熟休止期T細胞の抗原受容体と一定以上の親和性で結合

出来る場合に、免疫応答は開始する。MHCはclass Iとclass IIに分類される。 $\alpha$ 鎖と $\beta$ 鎖からなる受容体を持つT細胞(末梢リンパ組織の大多数)はMHC class Iに反応するCD8 T細胞と、class IIに反応するCD4 T細胞に2分される。MHC class I分子は全ての体細胞表面に表現されており、原則的に細胞内で産生されるタンパク質(内因性抗原)の消化断片を結合する。CD8 T細胞は活性化されると対応抗原を提示する細胞を殺す、細胞障害性T細胞となる。これらは突然変異し癌化した自己細胞や、ウイルス感染細胞の排除に必須の役割を有する。一方CD4 T細胞は、主として免疫反応を調節する役割を持っている。例えば、B細胞が抗体を産生するようになるには、抗原刺激の他にCD4 T細胞からの助けを受ける必要がある。CD4 T細胞が認識するclass II MHC分子は、抗原提示細胞と称される特殊な細胞群のみが発現する。

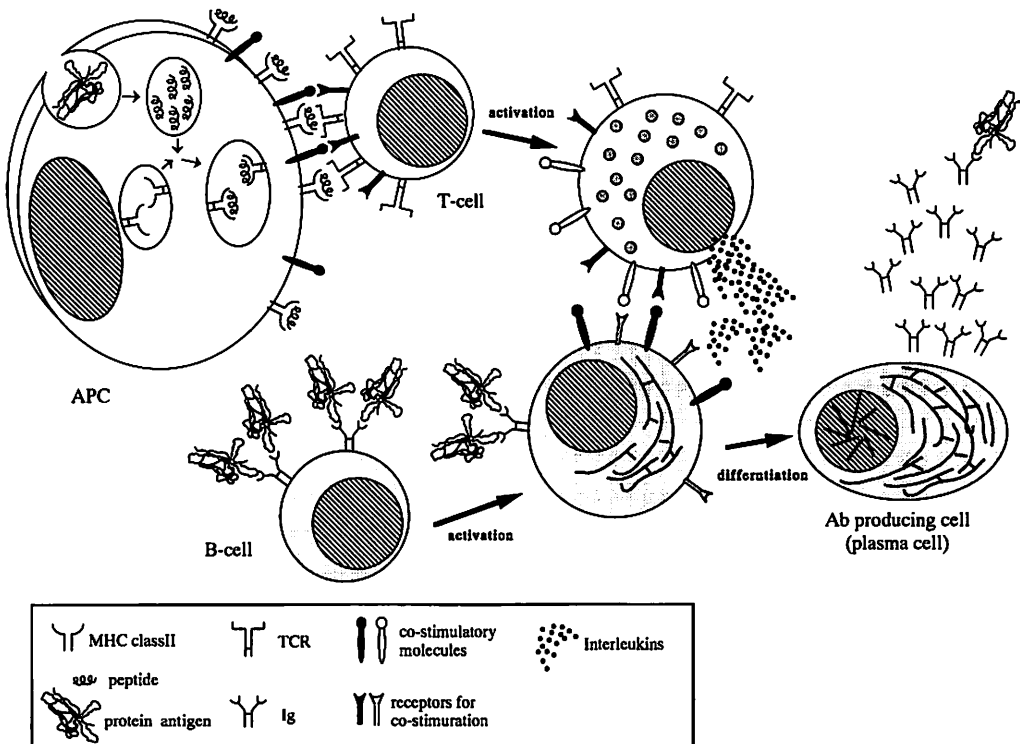


図7 外来タンパク質抗原に対する抗体産生系における細胞間相互作用。外来抗原は抗原提示細胞 (APC) に endocytosis もしくは phagocytosis により細胞内に取り込まれ、プロテアーゼにより消化され、ペプチド断片が MHC Class II 分子によって提示される。T細胞抗原受容体 (TCR) で MHC+ペプチドを認識し、副刺激を得たT細胞は活性化され、B細胞の活性化に必要なリンホカインや副刺激分子を発現する。一方タンパク質分子表層のエピトープを細胞表面 Ig により認識したB細胞がT細胞からの刺激を得ると、分裂増殖し、抗体産生細胞に最終分化する。図には示していないが、B細胞もまた抗原提示能を有する。

外来抗原は通常、抗原提示細胞内に取り込まれた後に細胞内プロテアーゼで消化され(プロセッシング)、その断片の一部が class II 分子と結合して細胞表面に提示され、T細胞による認識を待つ。外来タンパク質の特定の断片を結合した MHC class II に対して親和性の強い T細胞抗原受容体を有するクローンが活性化され、その結果 B細胞活性化に必要なシグナルを供給する。それは、インターリウキン(とりわけ IL-4,5,6)などの可溶性因子と、細胞表面上の CD40リガンド<sup>17)</sup>などである。また、CD4 T細胞の活性化の為に、MHC からの抗原受容体刺激のみでは不十分で、抗原提示細胞上の B7 と呼ばれる分子群と T細胞上の CD28 分子との結合をはじめ、一群の補助刺激分子の相互作用が必要である<sup>18)</sup>。以上の、外来抗原が侵入した時に誘導される、抗体産生に至る免疫応答における T細胞、B細胞、抗原提示細胞の相互作用を図 7 に模式的に示す。B細胞は、生のままの抗原分子の立体構造を含め、細胞外で消化分解された変性体の構造などあらゆる構造を認識し、活性化の前段階に入って T細胞からの指令を待つ。同時に、抗原提示細胞に表現された抗原由来オリゴペプチドを MHC class II 分子と共に認識した CD4 T細胞が活性化されることで免疫反応は作動するのである。

## VIII. 抗原提示細胞

本題から少し脱線するが、ここで抗原提示細胞とは何かを述べたい。それは MHC class II を細胞表面に発現する細胞の事を言う。定義に揺れも見られるが、原則として、恒常的に MHC class II を発現する細胞をプロフェッショナル抗原提示細胞と言う。樹状細胞(dendritic cells)、ランゲルハンス細胞、B細胞、それに恐らくはマクロファージの一部などがこれに相当する。ある刺激下(多くの場合インターフェロン $\gamma$ による刺激)でのみ class II 分子を発現するものがあり、これはノンプロフェッショナル抗原提示細胞と呼ばれる。血管内皮細胞、ケラチノサイト、線維芽細胞などが相当する。現在も免疫学の教科書においてさえも、「抗原提示細胞イコールマクロファージ、逆もまた真なり」の如くの記述を見ることがあるが、このように理解することは誤りである。

種々のタイプの抗原提示細胞の T細胞活性化能は、前項でも触れた副刺激分子の表現性に左右されている。現在最も高効率の抗原提示細胞であると考えられているのは樹状細胞であるが<sup>19)</sup>、この命名が我々の理解を混乱させる。この名は、顕微鏡観察下における形態的

特徴に対して与えられたものであり、外来抗原を提示できない樹状細胞も存在する。抗原提示細胞の代表的なものが樹状細胞であると言うことは正しいが、樹状細胞は抗原提示細胞であると言うと、また、必ずしも正確ではない。上皮内に存在するランゲルハンス細胞は抗原提示能を有する樹状細胞の一つの姿であると考えられている<sup>20)</sup>。B細胞も、特に 2次免疫応答における重要な抗原提示細胞である。抗原タンパク質の未変性高次構造を認識する B細胞は、抗原受容体を介して効率よく未変性抗原を取り込み、T細胞にペプチド断片を提示する<sup>21)</sup>。ノンプロフェッショナル抗原提示細胞では、多くの場合副刺激分子の発現が不十分である。副刺激の無い抗原受容体刺激は、T細胞を活性化するのは逆に、無応答性(アナジー)を誘導する<sup>18)</sup>ため、これらの細胞はむしろ免疫応答を負に調節する可能性が考えられる<sup>22)</sup>。

## IX. 高次構造依存性 B細胞エピトープ

既に何度も触れたが、抗原がタンパク質である場合、抗体の認識するエピトープは、アミノ酸の 1次配列の一部で表現可能なタイプと、3次や 4次の高次構造に依存するタイプのものが存在する<sup>23)</sup>。前者は、linear epitope, sequential epitope, continuous epitope などと様々に呼ばれ、後者は conformational epitope, discontinuous epitope などと呼ばれる。いずれの場合でも、抗体分子が認識するのはエピトープの立体構造上の特徴であることに違いはないが、その構造上の特徴が、1線に繋がったオリゴペプチドで表現できる時もあるが、そうでない場合もある。

近年、タンパク質抗原のエピトープマッピングが盛んに行われてきた。抗原物質のエピトープ部分だけを取り出す事ができれば、毒性などの生物活性を持たない安全なワクチンが合成できるというような、あるいは自己免疫疾患をエピトープ特異的に制御しようというような、理想的免疫療法を追求する上での試みである。その過程で使用されてきた方法論は、SDS-PAGE 展開後のイムノプロットや、合成オーバーラッピングペプチドを用いたものなどが中心であるが、これらの方法論は T細胞エピトープの同定には有効と考えられるものの、B細胞エピトープについては、linear なエピトープにしか対応できない。もちろん linear エピトープによって免疫応答を効果的に制御できる場合があり、そのような成功例が報告されてきた<sup>24-27)</sup>。しかし、conformational エピトープに対する抗体が決定的に重要であり、linear エピトープは



臨床的に無価値である場合もある。例えば、リウマチ性関節炎との関わりが疑われるⅡ型コラーゲンに対する抗体や<sup>28, 29)</sup>、SLEの一部に随伴する抗PCNA (proliferating cell nuclear antigen) 抗体などの自己抗体<sup>30, 31)</sup>では、高次構造依存性エピトープが重要な意味を持つと考えられているし、タンパク質抗原ではないが、やはりSLEとの関連で有名な抗DNA自己抗体でも、1本鎖DNA抗体ではなく2本鎖DNAに向かう抗体に病因論的意義が認められる。歯周感染でも、歯周炎患者の*Porphyromonas gingivalis*線毛に対する抗体は、線毛ポリマーには強く反応するものの線毛モノマーにはあまり反応しないと報告されている<sup>32)</sup>。

リゾチームをモデル抗原として、linear epitopeとdiscontinuous epitopeの出現頻度を数学的、理論的に求めた研究があるが、linearなものでは僅かしか表現され得ないと結論づけられている<sup>33)</sup>。筆者が行った実験でも、リゾチームや*P. gingivalis*線毛を含めて、抗原が安定な3次あるいは4次の高次構造を有する場合には、それらを抗原として生体内で誘導される抗体産生細胞クローンの圧倒的大部分がconformationalエピトープに対するクローンで占められるという結果を得た<sup>33)</sup>。

抗体が抗原エピトープの立体構造を認識するという性質においては、抗原が多糖であれ脂質であれ共通のことであるが、タンパク質の場合には、折り紙細工のように正確にかつ複雑に折り畳まれている(folding)事が多く、B細胞エピトープを探索する場合にもこのfolding patternを考慮する必要がある。タンパク質の基本設計図は遺伝子、すなわちDNAの1次配列であるので、1次配列がfolding patternを規定しているはずと信じ、1次構造と3次構造を関係付ける法則性を見つけようと、構造生物学者らは熱心に取り組んでいる。今のところ法則性とまで言えるようなものは何もわかっていないに等しいようであるが、近い将来に飛躍的進展が得られるものと、筆者は大きな期待を寄せている。

構造生物学の現状がこのような段階であるので、免疫学において高次構造依存性エピトープを同定するのは容易な作業ではない。そんなわけで、より結果の得やすいlinear epitopeが研究対象として取り上げられる傾向が強かったとも考えるのだが、高次構造依存性エピトープに関する研究も地道に続けられており<sup>34-36)</sup>、これらが提供する知見は、期待される構造生物学の進歩と協調して、合成ワクチン開発のためのより合理的な戦略の立て方を示してくれるに違いない。

## X. おわりに

免疫系の抗原認識において、タンパク質抗原の1次から4次までの構造がどのような意味を持つものかを中心に、抗原提示の問題も含めつつ、現在確立され今後もまず変更されないと思われる事柄を極力簡単に整理したつもりである。私は大学院に入学した1983年以来一貫して免疫学、中でも抗体産生に関わる研究に携わってきたつもりであるが、所属が変わる毎に標榜上の専門領域名が変わり(歯周病学→生化学→予防歯科学)その都度、視点は保ちつつも研究材料や表現方法を変えざるを得なかった。そんな事もあって、自らの研究成果を軸にして一編の総説を記す事に困難を感じた為、本稿はいささか入門書的な解説になってしまったきらいもあるがご容赦願いたい。

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## 文献

- 1) Tonegawa, S.: Somatic generation of antibody diversity. *Nature* 302, 575-581, 1983
- 2) Köhler, G. & Milstein, C.: Continuous cultures of fused cells secreting antibody of predefined specificity. *Nature* 256, 495-497, 1975
- 3) Rajewsky, K.: Clonal selection and learning in the antibody system. *Nature* 381, 751-758, 1996
- 4) Amit, A. G., Mariuzza, R. A., Phillips, S. E. & Poljak, R. J.: Three-dimensional structure of an antigen-antibody complex at 2.8 Å resolution. *Science* 233, 747-753, 1986
- 5) Bentley, G. A., Boulot, G., Riottot, M. M. & Poljak, R. J.: Three-dimensional structure of an idiotope-anti-idiotope complex. *Nature*

- 348, 254-257, 1990
- 6) Chitarra, V., Alzari, P. M., Bentley, G. A., Bhat, T. N., Eisele, J. L., Houdusse, A., Lescar, J., Souchon, H. & Poljak, R. J.: Three-dimensional structure of a heteroclitic antigen-antibody cross-reaction complex. *Proc. Natl. Acad. Sci. USA* 90, 7711-7715, 1993
  - 7) Bhat, T. N., Bentley, G. A., Boulot, G., Greene, M. I., Tello, D., Dall'Acqua, W., Souchon, H., Schwarz, F. P., Mariuzza, R. A. & Poljak, R. J.: Bound water molecules and conformational stabilization help mediate an antigen-antibody association. *Proc. Natl. Acad. Sci. USA* 91, 1089-1093, 1994
  - 8) Lescar, J., Pellegrini, M., Souchon, H., Tello, D., Poljak, R. J., Peterson, N., Greene, M. & Alzari, P. M.: Crystal structure of a cross-reaction complex between Fab F9.13.7 and guinea fowl lysozyme. *J. Biol. Chem.* 270, 18067-18076, 1995
  - 9) Fields, B. A., Goldbaum, F. A., Ysern, X., Poljak, R. J. & Mariuzza, R. A.: Molecular basis of antigen mimicry by an anti-idiotope. *Nature* 374, 739-742, 1995
  - 10) Holmes, M. A. & Foote, J.: Structural consequences of humanizing an antibody. *J. Immunol.* 158, 2192-2201, 1997
  - 11) Oakley, A. J., Lo, B. M., Ricci, G., Federici, G. & Parker, M. W.: Evidence for an induced-fit mechanism operating in pi class glutathione transferases. *Biochemistry* 37, 9912-9917, 1998
  - 12) Ito, H.-O., Ueda, T., Hashimoto, T., Imoto, T. & Koga, T.: Quaternary structure-dependent idiotope and antigen binding of a monoclonal antibody specific for conformational epitope on type II collage. *Cell. Mol. Life Sci.* 53, 51-60, 1997
  - 13) Garcia, K. C., Degano, M., Stanfield, R. L., Brunmark, A., Jackson, M. R., Peterson, P. A., Teyton, L. & Wilson, I. A.: An alpha-beta T cell receptor structure at 2.5 Å and its orientation in the TCR-MHC complex. *Science* 274, 209-219, 1996
  - 14) Garboczi, D. N., Ghosh, P., Utz, U., Fan, Q. R., Biddison, W. E. & Wiley, D. C.: Structure of the complex between human T-cell receptor, viral peptide and HLA-A2. *Nature* 384, 134-141, 1996
  - 15) Jameson, S. C., Hogquist, K. A. & Bevan, M. J.: Positive selection of thymocytes. *Annu. Rev. Immunol.* 13, 93-126, 1995
  - 16) 多田富雄: 免疫の意味論, 青土社, 東京, 1993
  - 17) Van den Eertwegh, A. J., Noelle, R. J., Roy, M., Shepherd, D. M., Aruffo, A., Ledbetter, J. A., Boersma, W. J. & Claassen, E.: In vivo CD40-gp39 interactions are essential for thymus-dependent humoral immunity. I. In vivo expression of CD40 ligand, cytokines, and antibody production delineates sites of cognate T-B cell interactions. *J. Exp. Med.* 178, 1555-1565, 1993
  - 18) Schwartz, R. H.: A cell culture model for T lymphocyte clonal anergy. *Science* 248, 1349-1356, 1990
  - 19) Cella, M., Sallusto, F. & Lanzavecchia, A.: Origin, maturation and antigen presenting function of dendritic cells. *Curr. Opin. Immunol.* 9, 10-16, 1997
  - 20) Peguet, N. J., Moulon, C. & Schmitt, D.: The antigen presenting capacity of human epidermal Langerhans cells. *Cell. Mol. Biol. (Noisy le grand)* 1, 15-20, 1994
  - 21) Lanzavecchia, A.: Antigen-specific interaction between T and B cells. *Nature* 314, 537-539, 1985
  - 22) Nickoloff, B. J. & Turka, L. A.: Immunological functions of non-professional antigen-presenting cells: new insights from studies of T-cell interactions with keratinocytes. *Immunol. Today* 15, 464-469, 1994
  - 23) Barlow, D. J., Edwards, M. S. & Thornton, J. M.: Continuous and discontinuous protein antigenic determinants. *Nature* 322, 747-748, 1986
  - 24) Burnie, J. P., Brooks, W., Donohoe, M., Hodgetts, S., al, G. A. & Matthews, R. C.: Defining antibody targets in *Streptococcus oralis* infection. *Infect. Immun.* 64, 1600-1608,

- 1996
- 25) Baughn, R. E., Jiang, A., Abraham, R., Ottmers, V. & Musher, D. M.: Molecular mimicry between an immunodominant amino acid motif on the 47-kDa lipoprotein of *Treponema pallidum* (Tpp47) and multiple repeats of analogous sequences in fibronectin. *J. Immunol.* 157, 720-731, 1996
- 26) Mechin, M. C., Rousset, E. & Girardeau, J. P.: Identification of surface-exposed linear B-cell epitopes of the nonfimbrial adhesin CS31A of *Escherichia coli* by using overlapping peptides and antipeptide antibodies. *Infect. Immun.* 64, 3555-3564, 1996
- 27) Lotter, H., Zhang, T., Seydel, K. B., Stanley, S. J. & Tannich, E.: Identification of an epitope on the *Entamoeba histolytica* 170-kD lectin conferring antibody-mediated protection against invasive amebiasis. *J. Exp. Med.* 185, 1793-1801, 1997
- 28) Stuart, J. M., Townes, A. S. & Kang, A. H.: Nature and specificity of the immune response to collagen in type II collagen-induced arthritis in mice. *J. Clin. Invest.* 69, 673-683, 1982
- 29) Terato, K., Hast, K. A., Reife, R. A., Cremer, M. A., Kang, A. H. & Stuart, J. M.: Induction of arthritis with monoclonal antibodies to collagen. *J. Immunol.* 148, 2103-2108, 1992
- 30) Brand, S. R., Bernstein, R. M. & Mathews, M. B.: Autoreactive epitope profiles of the proliferating cell nuclear antigen define two classes of autoantibodies. *J. Immunol.* 152, 4120-4128, 1994
- 31) Brand, S. R., Bernstein, R. M. & Mathews, M. B.: Trimeric structure of human proliferating cell nuclear antigen. Implications for enzymatic function and autoantibody recognition. *J. Immunol.* 153, 3070-3078, 1994
- 32) Yoshimura, F., Sugano, T., Kawanami, M., Kato, H. & Suzuki, T.: Detection of specific antibodies against fimbriae and membrane proteins from the oral anaerobe *Bacteroides gingivalis* in patients with periodontal diseases. *Microbiol. Immunol.* 31, 935-941, 1987
- 33) Ito, H.-O. et. al.: Immunodominancy of conformation-dependent B-cell epitopes of protein antigens. (投稿中)
- 34) Schulte, S., Unger, C., Mo, J. A., Wendler, O., Bauer, E., Frischholz, S., von der Mark, K., Kalden, J. R., Holmdahl, R. & Burkhardt, H.: Arthritis-related B cell epitopes in collagen II are conformation-dependent and sterically privileged in accessible sites of cartilage collagen fibrils. *J. Biol. Chem.* 273, 1551-1561, 1998
- 35) Gao, B. & Esnouf, M. P.: Elucidation of the core residues of an epitope using membrane-based combinatorial peptide libraries. *J. Biol. Chem.* 271, 24634-24638, 1996
- 36) Korth, C., Stierli, B., Streit, P., Moser, M., Schaller, O., Fischer, R., Schulz-Schaeffer, W., Kretzschmar, H., Raebler, A., Braun, U., Ehrensperger, F., Hornemann, S., Glockshuber, R., Riek, R., Billeter, M., Wuthrich, K. & Oesch, B.: Prion (PrP<sup>Sc</sup>)-specific epitope defined by a monoclonal antibody. *Nature* 390, 74-77, 1997



## Early Buddhist Ethics and Modern Science: Methodology of Two Disciplines

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### Abstract:

A conventional notion regarding "ethics" and "natural science" is that they are fundamentally different intellectual disciplines, in which "ethics" is the study of values dealing with the concepts of "ought" or "should" (rooted in the dichotomous of "good/evil" or "right/wrong"), while "natural science" is value-free research which attempts to deal with "is," "facts," or phenomena.

This article argues that the above view is one-sided if examined from an Early Buddhist perspective. The Early Buddhist canonical texts introduced an ethical system that was non-prescriptive and non-judgmental that dealt with "is" without utilizing concepts or terms that connote "good/evil." They explained its moral system by the notion of "health" by utilizing the law of causality obtained through direct observation of phenomena. These texts not only presented a moral system based upon the principle of causality, but also enjoined others to experiment, examine, verify, realize, and replicate it. This article discusses some similarities and differences between the Early Buddhist methodologies and those of contemporary dental/medical science. For Early Buddhists, "health" meant "mental health," while for dentistry or medicine it means "oral or physical health." For the former, the goal was the "normalization" of mental functions that "normalize ethical behavior," while for the latter it is the "normalization" of oral or physical functions.

In conclusion, this article demonstrates how Early Buddhists used ethics as a scientific discipline to understand the nature of the ethical world and that it was not different from other scientific disciplines that are applied to the physical world today.

### Key words:

ethics, dental medicine, causality, Buddhism, natural science

### Introduction

For students of the Buddhist Pāli Nikāya texts, it is surprising to find the following statement at the very outset of the article under the entry of "ethics" as representing the scope of ethics in the *Encyclopaedia of Religion and Ethics*, the most authoritative encyclopedia in the area of the study

regarding ethics and religion:

Everything may be looked at from two different points of view. We may take it simply as it is, seeking to discover how it came to be the thing it is, and how it is related to other things; or we may compare it with some ideal of what it ought

to be . . . Corresponding to these two aspects of things, which we may call respectively fact and ideal, we have two kinds of sciences -- those which concern themselves with the description and explanation of things as they are, and those which concern themselves with our judgments upon them. The former class has sometimes been called 'natural,' the latter 'normative' or, as is better, 'critical' sciences.

Ethics is critical in the sense explained.<sup>2</sup>

Setting aside a philosophical discussions of ethics, the above statement seems generally representative of a conventional perception of ethics that is widely accepted in the arena of Western ethics even today.<sup>3</sup> The underlying view is that ethics and natural science or physical science are two different sciences or intellectual disciplines.<sup>4</sup> In such a paradigm, ethics is seen as a value judgment that attempts to deal with "normative" or "ought,"<sup>5</sup> while science is as a value-free research that attempts to deal with "is" or phenomena. Thus, it is believed that the fields of research of ethics and science are fundamentally different from each other. The implication seems to be that ethics neither can nor should deal with scientific approaches and that science neither can nor should deal with ethical approaches. The purpose of this paper is (A) to show how the system of Early Buddhist ethics differs from the common notion of Western ethics and (B) to emphasize that mutual cooperation between ethics and science is needed.

Let us suppose that there is a system of ethics that is not directly a value judgment and primarily deals with "is." In this ethics, first of all, one does not find concepts of "good/evil" or terms that connote "good/evil." This ethics utilizes the principle of causal conditionality, as the basis of its moral system. Also suppose that this ethics, in providing its ethical principles and its moral system, utilizes factual knowledge obtained through such methodologies as direct observation, experimentation, verification and replication in search

of ethical truth or ethical facts. In this paradigm, ethics and science are regarded as similar intellectual disciplines with similar fact-finding methods.

These ideas are not awkward or surprising to those who understand ethics as Early Buddhists<sup>6</sup> did. On the contrary, students of Early Buddhist ethics, and perhaps Early Buddhists themselves, had they known the concept of science, would likely consider this dichotomy between science and ethics as unrealistic and undesirable, and they would likewise consider the above cited statement of the famous encyclopedia as inapplicable to Buddhist ethics. For them, science and ethics would hardly be regarded as two different intellectual disciplines.

Indeed, significant resemblances of approach and methodology between Early Buddhism and science have been noticed, so much so, that Buddhism is presented as empiricism by some scholars.<sup>7</sup> The Buddhist empiricism thesis and its controversy are ongoing.<sup>8</sup> Unfortunately, however, these arguments and discussions are solely in a philosophical vein. They discuss subjects such as incarnation after life, extra-sensory perception or reidentification of a deceased person. None of these discussions have focused on the psychological and ethical perspective of Buddhism, the main emphasis of Early Buddhism.

Since the mid-19th century, in the field of science, close observation and experimentation have been considered as "the central plank of all scientific work."<sup>9</sup> But, on the other hand, a rigorous experimental testing of a scientist's hypotheses themselves also began to be emphasized.<sup>10</sup> Today, scientific research is defined as "a mixture . . . of logical construction and empirical observation, these components standing in a roughly dialectical relation,"<sup>11</sup> and modern science is perceived as "far more a form of enquiry into natural phenomena."<sup>12</sup> Thomas S. Kuhn states that the traditional theorem of the separation of "is" and "ought" is, in practice, no longer honored.<sup>13</sup> Indeed, in the field of modern science, the above dichotomical perspective of phenomena or reality began to be

perceived as no longer acceptable. Now, it is even said that “to call science ‘knowledge,’ with the implication of certainty, is an idea long past its prime.”<sup>14</sup> One may even see the replacement of scientific realism with scientific relativism, questioning the possibility of objectivity in any scientific endeavour.<sup>15</sup> In considering these circumstances, it is interesting that Early Buddhists utilized the similar scientific methodologies in obtaining knowledge of ethics (Dhamma) to solve the human problems and formulated the moral system, and yet claimed universality of Dhamma beyond the historical context.

This essay will analytically examine the methodologies and approaches that Buddhists utilized in presenting Dhamma, particularly the Dhamma of ethics. The examination may open a new perspective not only on the Buddhist empiricism thesis, but also on a new relationship between ethics and science that may embody a potential unity of these two intellectual disciplines. Such an examination will not only directly and indirectly recast the entire Buddhist tradition itself in a broader context, but also raise some fundamental questions about the study of religion in general.

This essay is neither a comparative study of science and Buddhism nor of Western ethics and Buddhist ethics. This paper limits the scope of its examination to some basic similarities observable in the methodologies that both Buddhism and science adopt in search of truth. Further, whenever the term “Buddhism” is used in this essay, it refers to the Buddhism depicted in the Pāli Nikāya texts, which is known as Early Buddhism. Although to some the term “Early Buddhism” may suggest an ancient form of Buddhism no longer extant, “Early Buddhism” is still studied and followed as a living tradition in contemporary Theravāda Buddhist countries such as Sri Lanka, Burma or Thailand. While the Theravāda Buddhist tradition embodies the later commentaries, the present essay focuses exclusively on the Pāli Nikāya texts.

## I. Early Buddhist Position towards Their Texts

### 1. Texts as People’s Records: Non-Revelatory Texts

The Pāli Nikāya texts as “religious texts” have several distinctive characteristics. First of all, for the Pāli Nikāya authors, language was strictly a tool for communication. The Buddha is said to have discouraged the habit of regarding his words as sacrosanct and forbidden their “Sanskritization” and chanting after the Vedic manner.<sup>16</sup> Secondly, the Pāli Nikāya texts are people’s records: They are not only record of words of the Buddha but also of his disciples and followers. In the *Saccavibhanga sutta*, for example, the Buddha, after giving a short talk, goes away, and then, his disciple, Sāriputta, elaborates on what the Buddha said. On many other occasions, when his disciples (including house-holders or their wives) make a sensible statement, the Buddha applauds and approves by saying, “Well said” or “If I said it, I would have said it in exactly the same way.”<sup>17</sup> Thirdly, the Nikāya texts themselves proclaim a delimitation on the value of the texts, by using the stock phrase “Thus is heard by me” (*evam me sutam*),<sup>18</sup> instead of “The Buddha said . . .” at the beginning of each sutta. This is tantamount to an admission by the authors of the texts that these texts are, so to speak, second-hand information (teachings).<sup>19</sup> They abandon the claim of “authority” of a “sacred” text or even the claim to be direct records of the “word of the Buddha” (*buddhavacanam*). The stock phrase is also employed to distinguish the Buddhist texts from other religious texts. In the Mahāyana literature, however, the same stock phrase, “*evam me sutam*,” is adopted rather to denote that the sutras in the texts are the direct teaching of the Buddha himself.<sup>20</sup> Fourth, since they are second-hand information (teachings), the Nikāya authors deemed it necessary to have criteria for making these texts as accurate as possible so that they could become as close as possible to the first-hand information given by the Buddha himself. Buddhist Councils, which were carried on from time to time during the period of oral tradition, were conducted to seek agreement in justifying the

use of the above stock phrase of "Thus is heard by me" (*evam me sutam*). They established a certain set of criteria for the approval and acceptance of a particular teaching as Dhamma, qualified to be introduced by "*evam me sutam*." The sutta calls this set of criteria "*mahāpadesa*" ("great authorities" or "true authorities").<sup>21</sup> The compilers of the texts must have regarded such a procedure as necessary to avoid the confusion or misquotation that students of later generations might become liable to.

The above mentioned characteristics of the texts show that the Pāli Nikāya texts do not claim to be a revelation. Buddhism differs from the Vedic tradition which gained its authority through belief in divine revelation. They also indicate that the Early Buddhists' primary concern regarding their texts was precision, accuracy and clarity of the literary contents. Unlike the later canonical texts of Mahāyāna Buddhism, the Pāli Nikāya texts are written with substantial coherency and unity on doctrinal issues with prosaic and simple expression. The notion of *nibbāna*, for example, the ultimate goal of the teachings of the Buddha, as it appears in the Pāli Nikāya texts, is not metaphysical, mystical or symbolic.<sup>22</sup> These aspects are also closely related to the issue of interpretation of the texts.

## 2. Freedom of Interpretation

The Pāli Nikāya texts themselves did incorporate some minimal guidelines for disputation over the doctrine with regard to textual interpretation of meanings and words. The *Kinti sutta*,<sup>23</sup> for example, presents a very basic criterion of interpretation: Dhamma is for the purpose of ending suffering. Dhamma is not practiced in expectation of future happy existence or for the sake of material gain. Another sutta offers basic misconceptions (*vipallāsas*) which should be avoided in reading: (1) To hold that there is permanence when there is impermanence; (2) to hold that there is happiness when there is suffering; (3) to hold that there is substantiality where there is no substantiality; and (4) to hold

that there is pleasantness in that which is foul.<sup>24</sup> All of these are so basic and essential, and, consequently, so definitive and clear-cut that they seem targetted against gross misreadings rather than guidelines for interpretation. The implication seems to be that Buddhists have almost no interest in engaging in textual exegesis and interpretation. The purpose of setting these criteria is to eliminate erroneous reading of the text and/or to guide the reader to a correct comprehension of the texts, instead of formulating sophisticated strategies of interpretations. One may even say that Early Buddhists allow freedom of interpretations, except for fundamental mis-understandings and mis-readings. This aspect is noteworthy in the context of a strong interest in hermeneutical issues of the later Mahāyāna literature and also of the current academic interest of modern Western hermeneutics.

Early Buddhists' lack of attention to interpretation is clear when we compare it with the later Mahāyānists' enthusiasm toward interpretation. As Peter Gregory states, for Chinese Buddhists, interpreting the various teachings became "more urgent and, at the same time, more complex as Buddhism developed doctrinally and spread geographically."<sup>25</sup> The situation that necessitated complicated hermeneutical strategies arose from various conditions:

The hermeneutical problem as it presented itself to Chinese Buddhism was how the bewildering welter of teachings to which they were heir could be reconciled with one another into a single, coherent, internally consistent, doctrinal whole. The problem was at once more pressing and more complicated for the Chinese than for their Indian brethren. The different sects that arose in India were all an organic part of the evolving cultural matrix out of which Buddhism developed. Even though they often disputed with one another, they could all claim some form of linkage to the historical Buddha. The cultural and historical



continuity made it unnecessary for them to account for the teachings of the other sects in a systematic fashion. In China, however, Buddhism was very much an alien religion that violated many of the most central values of Chinese culture. It therefore continually had to justify its presence within Chinese society. Furthermore, since the scriptures contained in the diverse collection introduced into China were all believed to have been spoken by the Buddha, and were thus all sacred as the Buddha's word (Buddhavacana), Chinese Buddhists felt compelled to devise a systematic framework to account for the tradition as a whole.<sup>26</sup>

Apparently, the later Mahāyāna literature presented different problems of interpretation from those of the Early Buddhist literature. However, these historical, cultural, geographical and textual reasons for the Early Buddhists' lack of interest in interpretation seem subordinate to a major cause, the Early Buddhists' scientific methodologies and approaches to Dhamma. We will come back to this issue later.

### 3. Freedom from Interpretation

Early Buddhists regarded interpretation as nothing but a distortion of information, albeit mostly unconscious.<sup>27</sup> According to them, due to the interpretive mechanism of ordinary human consciousness, so-called understanding is problematic by nature. The Pāli Nikāya's position is that interpretation or distortion of information is caused not by external factors, such as historical/social factors, but by one's own mental activity called *sankhāra*. *Sankhāra* is the function of mind that is accumulating, editing, and interpreting in-coming information. The goal to which the Pāli Nikāya texts aspire is defined as seeing "phenomenon as it comes to be" or seeing "phenomenon as it is" (*yathābhūta*), seeing phenomenon without interpretation. *Yathābhūta ñāna* (the knowledge of *yathābhūta*) is the highest

knowledge of seeing phenomenon, being completely freed from interpretation. Early Buddhists have a suspicion of interpretation and aspire to be free from any sort of interpretation in order to see reality as it comes to be or as it is. For them, interpretation is a problem not only in the realm of intellectual discipline, but in the existential and soteriological sphere.

### 4. Rejection of Belief, Pure Logic, Reason, Texts, Authority, Tradition, Respect, etc.

Buddhism does not consider itself a belief-system. It exhorts one to be suspicious not only of belief,<sup>28</sup> but also of reason, tradition, reports, texts, or scriptural authority. The *Kesamutti sutta*, known also as *Kālāma sutta*, clearly articulates this position. The Buddha is reputed to have answered as follows, being asked about the criterion for evaluating a certain theory, by the people of Kālāma, who were said to be highly intellectual:

Be ye not misled by reports or traditions or hearsay. Be not misled by proficiency in collections [on the authority of the scriptures], nor by mere logic or inference, nor after considering reasons, nor after reflection on and approval of some theory, nor because it fits becoming [seeming possibilities], nor out of respect for a recluse (who holds the idea). But, Kālāmas, *when you know for yourselves* that certain things are unprofitable, unwholesome, blameworthy, censured by the wise; these things, *when performed and undertaken*, conduce to loss and sorrow, then reject them: *when you know for yourselves* that certain things are profitable, wholesome, blameless, praised by the wise; these things, *when performed and undertaken*, conduce to profit and happiness, then abide therein [Emphasis added].<sup>29</sup>

The passage describes the four steps in evaluating and accepting a certain theory: (1) One evaluates

a theory not relying on words, language, tradition, belief, custom, reasons, logic, interpretation, authority, or any other external sources; (2) One evaluates the theory based on whether or not it is profitable, wholesome, blameless, praised by the wise; (3) One evaluates the theory based on whether it conduces to sorrow or to happiness; (4) One accepts the theory when the theory conduces to happiness.

The repeated use of such expressions as “when you know for yourselves” and “when performed and undertaken” indicate Buddhists’ strong reliance on an empirical approach by and for oneself. Although to get a better understanding, one may refer to others who are more learned in obtaining information about the theory, one should always personally experiment and experience it to determine whether one should accept it or reject it. The sutta also advocates that when the theory is verified to be beneficial and profitable by one wise person, the test should be still to be done by and for oneself. Here, sharing information and sharing experience are strictly separated. The reliable verification, according to them, comes from one’s own participation in examination and experiment. And the final test is whether the theory conduces to sorrow or to happiness. A thorough empiricism<sup>30</sup> is required here.

This position is also specifically observed in the Early Buddhist attitude towards reason. K. N. Jayatilleke categorizes the Early Buddhists’ four possibilities of the relationship between actual facts and human reason: (1) well-reasoned true (*sutakkitaṃ tathā*), (2) well-reasoned false (*sutakkitaṃ aññathā*), (3) ill-reasoned true (*duttakkitaṃ tathā*) and (4) ill-reasoned false (*duttakkitaṃ aññathā*).<sup>31</sup> Even when reason is valid, in the phenomenal world or in reality it could be true or false. They saw reason as a mere source of knowledge that is not always reliable but something with limited use in finding truth. It is also possible that an ill-reasoned theory may be true in the light of contingent facts. For Buddhists, what counts is not the validity of logic, reasoning, or interpretation, but the factuality.

Jayatilleke claims that for Buddhists, a theory, information, or statement in which no verification or no experimental content is attached by the speaker is in fact meaningless.<sup>32</sup> In Early Buddhist understanding, truth or falsity of a theory in relation to phenomenon cannot be judged by the reasoning or logic, but by a personal empirical verification.

It is noteworthy that, as we will see later, Early Buddhists applied the method of individual empirical verification not only to any theory in general, but more importantly to Dhamma, the teaching of the Buddha. They enjoined thorough inspection, examination and verification of Dhamma.

## II. Early Buddhist Position towards Phenomena

### 1. Dhamma is a Discovery

According to a Pāli Nikāya text, the Buddha discovered Dhamma.<sup>33</sup> The textual expression is that Dhamma had been discovered, just as an ancient city, hidden in a deep forest unknown to anyone, but always being there, has been discovered.<sup>34</sup> The text also states that Dhamma would operate whether the Buddha ever discovered it or not.<sup>35</sup> Usually, these textual references are understood symbolically. For example, scholars paraphrase them as follows: “[t]he Buddhist Dharma [Dhamma] is not dependent on the historical event of Śākyamuni [Buddha]’s enlightenment, ministry, or nirvāna,”<sup>36</sup> or “[i]t is not the historicity of Gotama which supports Buddhism, unlike the situation with Christianity,”<sup>37</sup> where “if it could be shown that the Biblical Jesus did not exist Christianity would be undermined.”<sup>38</sup> None of them, however, seems capture the fundamental point of the textual statement: Dhamma is a discovery.

Setting aside the doctrinal discussion of the content of the Buddha’s discovery, one point to be mentioned first is that for Buddhists a primary concern is the contents of the theory (Dhamma) rather the person who discovered it, as the above cited scholars point out. For Buddhists, the role that the founder plays is rather minor compared

to that of other religious traditions. Nathan Katz says that unlike in Jainism, and, perhaps, unlike all other religious traditions, in Buddhism, there is no restriction of a particular epithet only for the Buddha: There is a significant identity of the Buddha and the *arahant* in the earliest Pāli Nikāya texts, except some basic distinction, such as that the Buddha is the founder and the *arahant* is the follower.<sup>39</sup> Thus, the same kind of epithets are applied to both the Buddha and an *arahant*. Hajime Nakamura also says that in the earliest extant Buddhist texts, we cannot find the term that designates “disciples” (*antevāsīn*). Whether as a concept or as an expression, “the Buddha’s disciple” does not exist in Early Buddhism.<sup>40</sup> This is also an indication that Early Buddhists emphasize more the discovered theory itself (Dhamma) rather than its discoverer (the Buddha). The Buddha’s primary role was to explain the discovered theory (Dhamma) in a manner that many be benefited. In this sense, the Buddha himself may be an interpreter of Dhamma, as Robert Thurman points out.<sup>41</sup>

Secondly, Early Buddhists enjoin a certain detachment and objectivity also in approaching Dhamma. According to the *Alagaddūgama sutta*, the Buddha advised not to hung onto Dhamma: Dhamma is to be taken only for its instrumental value, but not to be taken as a goal. In the sutta, it is analogously explained as: A raft is necessary only for crossing the river, after the crossing, no one carries it on the ground.<sup>42</sup> The sutta also tells that Dhamma should be taken carefully, just like a snake should be handled carefully. Dhamma could be harmful if wrongly taken, like a snake-catcher could be killed if he grasps a snake by the tail.<sup>43</sup> Along with statement of the aforementioned *Kālama sutta*, these accounts demonstrate Early Buddhists’ basic attitude to Dhamma and the Buddha: To discard both a historical belief in the Buddha and a blind belief in Dhamma.

## 2. Non-Speculation and Non-Metaphysics

As Mitsuyoshi Saigusa states, Buddhism has two characteristics in its approach towards

phenomena: (1) Non-metaphysical engagement and (2) direct and invariable observation (直視/凝視).<sup>44</sup> Indeed, Early Buddhists had disinterest in speculative and metaphysical questions. Buddhism regarded them as unverifiable, not utilitarian, and time wasting. According to the Early Buddhist texts, the Buddha did not answer the following ten metaphysical questions that interested the contemporary Indian philosophers. These ten can be categorized by the following four groups: regarding duration of the universe: (1) if the world is eternal and (2) if the world is not eternal; regarding extent of the universe: (3) if the world is finite and (4) if the world is infinite; regarding nature of the soul (*jīva*): (5) if the soul is identical with the body and (6) if the soul is different from the body; regarding the destiny of the *tathāgata* (an enlightened person): (7) if the *tathāgata* exists after death, (8) if the *tathāgata* does not exist after death, (9) if the *tathāgata* does and does not exist after death, and (10) if the *tathāgata* neither exists nor does not exist after death.<sup>45</sup>

Whatever answers might be given to these questions, they are not empirically verifiable by either observation or experimentation. David Kalupahana says that silence to these questions by the Buddha indicates his awareness of the limitation of empiricism.<sup>46</sup> If so, it also indicates that the Buddha and Early Buddhists strictly abstained from discussing issues that go beyond the limit of empiricism.<sup>47</sup> For the Buddha and Early Buddhists, a theory, information, interpretation, knowledge, or view does not constitute a valid theory, unless it is empirically verifiable.<sup>48</sup> Speculation about questions which are not empirically experimentable or verifiable are discouraged and ignored.

## 3. Dhamma: Description of Phenomena

A Buddhist premise that Dhamma operates regardless of its discovery immediately implies another distinctive aspect of Dhamma: Dhamma is descriptive. None of the major Early Buddhist doctrines, such as the theory of

Causal Conditionality (*paṭiccasamuppāda*), Non-substantiality (*anatta*), and Impermanence (*anicca*), bear either negative or positive connotations. They are flat descriptions of phenomena, free from evaluation, like science is essentially descriptive formulation.<sup>49</sup>

It is noteworthy that the descriptive nature of Buddhism is demonstrated even in the presentation of the ethical teachings. The process how a person gradually begins to learn to abstain from certain unethical behavior is described as follows by the Buddha:

In this matter, housefathers, the Ariyan disciple thus reflects: Here am I, fond of my life, not wanting to die, fond of pleasure (*sukha*) and averse from pain (*dukkha*). Suppose someone should rob me of my life (fond of life as I am and not wanting to die, fond of pleasure and averse from pain), it would not be a thing pleasing or delightful to me. If I, in my turn, should rob of his/her life one fond of his/her life, not wanting to die, one fond of pleasure and averse from pain, it would not be a thing pleasing or delightful to him/her. For a state that is not pleasant or delightful to me must be so to him/her also: and a state that is not pleasing or delightful to me, -- how could I inflict that upon him/her?

As a result of such reflection, he/she him/herself abstains from taking the life of creatures and one encourages others so to abstain, and speaks in praise of so abstaining.<sup>50</sup>

It is interesting that in the above explanation that stipulates the "ethical" teaching, no direct term that indicates "ought" or "should" is used. The reasoning of ethical teachings is deduced from one's direct observation of the reality of one's own and other's human nature and awareness of the causal relationship between self-love (*taṇhā*) and pleasure (*sukha*)/pain (*dukkha*). Thus, the basic formula of the ethical guidelines is given by

using the expression of "I take upon myself the rule of training to abstain from . . ." The direct observation and recognition can be compared to a "diagnostic" observation of the physician or the dentist of his/her patient after a thorough examination. This diagnostic direct observation turns into a prescription which is only a part of the description.

In Early Buddhism, a moral system is based upon the principle of the causal relationship between action and reaction, called the principle of *paṭiccasamuppāda* (Causal Conditionality or Dependent Co-arising). The principle of *paṭiccasamuppāda* is not only the central theory of Early Buddhism,<sup>51</sup> but has also been regarded as a core teaching of all Buddhist traditions throughout Buddhist history.<sup>52</sup> The fundamental principle that supports the Buddhist moral system can be formulated as follows:

When self-centeredness (*taṇhā*) is present, suffering (*dukkha*) is present; From the arising of self-centeredness (*taṇhā*), suffering (*dukkha*) arises; When self-centeredness (*taṇhā*) is absent, suffering (*dukkha*) is absent; On the cessation of self-centeredness (*taṇhā*), suffering (*dukkha*) ceases.<sup>53</sup>

The formula itself is a description of phenomena, and there is no value component. Since terms such as "*dukkha*" or "*taṇhā*" have been casually translated into English language such as "suffering" or "self-centeredness" to which no technical definition is rendered, one may wonder if "suffering" or "self-centeredness" is evaluative. Unlike the English terms "suffering" or "self-centeredness," "*dukkha*" and "*taṇhā*" are loaded with meanings that signify specific psychological or mental states, to which the Buddha and Early Buddhists provided highly technical definitions throughout the Nikāya texts.<sup>54</sup> In these original terms themselves, no evaluative connotation is rendered.

As I have mentioned at the beginning of this essay, ethics which deals with the norm or "ought" is considered to be a different discipline

from that of science which does not deal with the norm. Hence, a separation of ethics from science takes place in Western ethics. Dhamma, part of which is ethics, is a non-normative description of phenomena that states simply that “when A is present, B comes to be” or “when A is absent, B does not come to be.” Describing the reality of living beings, Dhamma states that each living being is most strongly attached to oneself<sup>55</sup> and all beings fear pain and harm and seek comfort and fearlessness.<sup>56</sup> Dhamma also states that self-love (*taṇhā*) and suffering (*dukkha*) arises together and ceases together. In this way, Dhamma is an explanation of causal conditionality of all phenomena, mental and physical (*paṭiccasamuppāda*).

From the entire mass of Dhamma, the Buddha only set forth Dhamma and emphasized that which is crucially relevant to discomfort and comfort in life.<sup>57</sup> In his selection of Dhamma, perhaps, his value-judgment is embedded. His manner of presentation of Dhamma, however, is as we have argued, descriptive, or may be prescriptive as is the case for a dentist or a physician. The role of the Buddha may be compared to the role of the Surgeon General in American society: From the entire collection of medical information obtained through scientific research, the Surgeon General who is a physician him/herself selects only relevant and necessary information and provides it to the public in order to prevent and cure illness and to promote health. Like the Surgeon General who is an advocate for health matters, the Buddha is an advocate for health matters, health in the mental realm. Though the Surgeon General him/herself is not an experimental scientist, in the case of Buddha, he is held to have accomplished the experimental research by himself and passed on the information to others. In both cases, of the Buddha and the Surgeon General, they only provide that information that is factual. The Surgeon General states, for example, “smoking by pregnant women may result in fatal injury, premature birth, and low birth weight.” Both the Buddha and the Surgeon General are the advocates

of health matters, but, they do not state, “should” or “should not.” And, it is a person him/herself who embeds a “value component” in the factual statement of “is,” when he/she him/herself finds value in it and takes it as an “advice.”

Gunapala Dharmasiri observes an evaluative element in Buddhist ethics. He divides a Buddhist ethical proposition into two parts, a “factual component” and a “value component,”<sup>58</sup> while saying that the factual component is extremely important. He says that the value component should be based on the factual component,<sup>59</sup> but it is unclear to me to which part of the Pāli Nikāya texts Dharmasiri directly refers to for the derivation of the term “value component,” for he does not specify. The only place he refers to is a passage from *Dhammapāda*.<sup>60</sup> The *Dhammapāda* is a collection of very short verses on the basics of Dhamma. Since its tone is proverbial rather than explanatory, it is difficult to seek therein for a substantial argument of this kind. But, even when imperative expression is used, the reasonings are provided.<sup>61</sup> If the rhetorically value-embedded expressions are to be found in the suttas, they are backed up with a solid factual component.

The goal of Buddhist ethics is to become a “*sīlavā*,”<sup>62</sup> a person in whom morality (*sīla*) is perfectly established as a spontaneous personality and whose behavior is virtuous and ethical by nature. In him/her, even a concept of “goodness” has disappeared. Such a person, without a sense of both externally and internally imposed “ought,” naturally, abstains from taking any inflicting action both with respect to oneself and others. In this regard, in the ethics of Buddhism, one can safely say that there is no “ought” component.

Regarding the descriptive nature of Buddhism, Frank J. Hoffman presented a different view: Buddhism is descriptive-cum-evaluative. His argument for this, however, relies upon his formulation of the proposition of “all is *dukkha*,”<sup>63</sup> which is not the Buddhists’. Based on this proposition, he further goes on to the discussion of pessimism and Buddhism.<sup>64</sup> His argument can be challenged from several angles. First of all, it is important

to note that the First Noble Truth (*dukkha-ariya-sacca*) or any other theory in the Nikāya texts never states that “all is *dukkha*.” The First Noble Truth says that “the five aggregates of attachment are suffering.” (*saṃkhittena pañca-upādāna-kkhandhā dukkhā*),<sup>65</sup> but does not say “the five aggregates are suffering.” “The five aggregates” (*pañca-kkhandhā*) and “the five aggregates of attachment” (*pañca-upādāna-kkhandhā*) are not the same thing.

It is important to mention, here, that the Buddhist notion of “the five aggregates,” too, bears no evaluative connotation, whether positive or negative. It is solely descriptive. In Buddhism the five aggregates (*pañca-kkhandhā*) are regarded as the constituents of the existence of all living beings. Therefore, a casual reading may make one assume that Buddhism signifies that “existence itself is suffering.” Hoffman states that “Since on the early Buddhist view the five aggregates and the corresponding faculties are all *dukkha*,”<sup>66</sup> “all the compound things are *dukkha* because impermanent.”<sup>67</sup> Hoffman’s idea seems to derive from the mixing up of two different things, “the five aggregates” (*pañca-kkhandhā*) and “the five aggregates of attachment” (*pañca-upādāna-kkhandhā*).<sup>68</sup> The message of the First Noble Truth is: “*dukkha* arises when *upādāna* (attachment) to the five aggregates (*pañca-kkhandhā*) arises,” but not “the five aggregates (*pañca-kkhandhā*) themselves are *dukkha*.” Hoffman’s argument is not based upon the Buddhist proposition depicted in the Nikāya, but his own evaluative proposition.

Following these argument, Hoffman discusses the Early Buddhist notion of “*yathābhūta*” (seeing the reality as it is). According to him, because of the “Buddhist” evaluative proposition, “*yathābhūta*” thereby means “seeing the reality in the Buddhist’s manner” that “all is *dukkhā*,” but not “seeing the reality as it is.” Then, he states as follows:

Seeing the early Buddhist way is regarded as seeing ‘*yathā bhūtam*’, ‘as it really is’, and not in some provisional way . . . To

see the world with Buddhist eyes as a suffering world replete with ignorance and craving is at once to see the world as a theatre of conflict in which right view may win out over wrong view in case one manages to attain liberation. To see the world *yathā bhūtam* is thus not to see what a video-camera would record, but is in part to see in a hopeful manner the possibility of liberation.<sup>69</sup>

His notion of “*yathābhūta*” expressed in the above passage may also be questioned.

The knowledge of “*yathābhūta*” is one of the most important notions of Early Buddhism, that represents the highest level of knowing reality. As I have discussed elsewhere, according to the *Madhupindika Sutta*,<sup>70</sup> there is a major problem in ordinary human perceptions which leads them to conflicts: When one receives new information, it is processed (*papañca*) and edited (*saṅkhāta*) in one’s mind in relation to previously stored information. As a result of this processing, there arises a flow of new thoughts and ideas. Influenced and dominated by these edited and processed ideas, one begins to react to the situation verbally, physically and mentally. Due to the problematic nature of cognitive and volitional activities of ordinary human consciousness, the object or information originally perceived through the senses is now distorted or contaminated by *papañca*. To obtain information accurately and to be able to respond to it correctly, one needs to focus on both the external conditions and the internal (mental) process that transform the incoming information. The individual’s capacity to correctly receive information both internally and externally is called “knowledge and vision of things as they come to be (*yathābhūta nana dassana*).” “*Yathābhūta*” means, therefore, not only perceiving external objects, but also directly seeing (*pajāñāna*) one’s internal mental process related to the external object as well. According to Early Buddhists, whatever one perceives becomes part of one’s conditioning; recognizing this fact

itself is very crucial. "*Yathābhūta nāna dassana*" therefore, technically speaking, is knowing and seeing "the reality as it comes to be," rather than "as it is," while, a video-camera, perhaps, only sees "the reality as it is." Hoffman's understanding of "*yathābhūta*" is one-sided and therefore, his allegation against "*yathābhūta*" is incomplete.

The descriptiveness and non-coerciveness of Dhamma are tied together. Buddhism neither imposes its propositions on others nor does it judge others who oppose its propositions. The teaching method of Early Buddhism is a gradual instruction (*anupubbikathā*).<sup>71</sup> Depending on a person's particular level of understanding, a particular instruction is given. Such a teaching method accommodates a person's existing level of understanding of Dhamma and proceeds further to higher and higher levels of understanding. Consequently, each level of instruction is provisional. Thus, the Buddha's attitude of presenting Dhamma to listeners or students is not coercive. This is also what the aforementioned *Kālāma sutta* and the parable of a raft in the *Alagaddū gama sutta* postulate. Buddhism would not advocate cursing or condemning those who find no truth in Dhamma. If a person does not find any truth in a Buddhist proposition, Early Buddhists would regard that person as needing more experience of life and more acute examination of reality and life. Early Buddhists were aware that to come to a conclusion such as "This alone is the truth, all else is falsehood" is a grave mistake.<sup>72</sup>

The descriptive nature of Dhamma prompted Early Buddhists to see it objectively and critically through examination, testing, observation, and verification. In what follows, I will further focus on the Early Buddhists' position towards Dhamma.

### III. Early Buddhist Position towards its Theory (i.e., Dhamma)

The term "Dhamma," which represents the "central concept of the Buddhist system,"<sup>73</sup> has many dimensions of meanings and scholars have

made remarkable attempts to define it.<sup>74</sup> As John Carter says, an attempt to determine the meanings of Dhamma in every occurrence in the canonical texts "would be an exhausting enterprise and universal agreement on conclusions proffered would be, perhaps, impossible."<sup>75</sup> There would be no single English word that is equivalent to the term "Dhamma" in the doctrinal and religious dimension of all Buddhist traditions,<sup>76</sup> but when it is rendered with "religious" connotations, it would mean "Universal Principle," "Salvific Truth," "Cosmic Law," "Nature," "Reality," and etc. The question is if Early Buddhists utilized scientific approaches and methods in dealing with human problems, what kind of position did they take towards their self-claimed truth of Dhamma? Hoffman discusses this issue from the view point of the unfalsifiability of a religious doctrine. According to him, in science, all propositions are falsifiable in principle, but "one characteristic of distinctively religious beliefs is their unfalsifiability in principle."<sup>77</sup> In other words, scientific propositions and hypotheses are testable (falsifiable) and religious doctrine and theories are untestable (unfalsifiable). Hoffman's position is that since Early Buddhism is religion, Buddhist Dhamma is never falsified.<sup>78</sup> In the following discussion, I will analytically investigate the Early Buddhists' approach to Dhamma, in examining Hoffman's argument.

#### 1. Early Buddhist Position towards the Theory (i.e., Dhamma) As Explanation of Universal Law (*Dhammatā*)

One of the sutta in the Nikāya postulates Dhamma as the object that the Buddha, the Fully Enlightened One (*sammāsambuddha*),<sup>79</sup> honored and respected as the "universal law,"<sup>80</sup> (*Dhammatā*) as his guide or master during the rest of his life after his enlightenment. The *Suttanipāta*, one of the oldest texts, also states that Dhamma's truthfulness is verified by the disciples of the Buddha and the realization of Dhamma was actually enjoyed by them.<sup>81</sup> In the Nikāya, Dhamma is also understood as the theory

of Causal conditionality (*paṭiccasamuppāda*): “Whoever sees *paṭiccasamuppāda* sees Dhamma, and whoever sees Dhamma sees *paṭiccasamuppāda*.”<sup>82</sup> Dhamma, the theory of *paṭiccasamuppāda*, is depicted as the universal law already established (discovered) by the Tathāgata.<sup>83</sup> These suttas apparently claim truthfulness, correctness and validity of Dhamma.

The question is: How do Early Buddhists claim validity and correctness of Dhamma? According to the Majjhima Nikāya, the Buddha himself, after his enlightenment, stated that he, too, like others, tested and experimented with other hypotheses, before enlightenment, while he was still the *bodhisatta*, all of which proved unsatisfactory.<sup>84</sup> He, Siddhattha Gotama, had many teachers who claimed that they had the final truth. But he discovered after testing that they were only highly developed hypotheses, but still incomplete.<sup>85</sup> The ascetic Gotama spent six years experimenting with different hypotheses, during this period of testing with trial and error. After empirical testings of and experiments with other theories which were found to be fruitless, he finally developed a new method and arrived at one final understanding.<sup>86</sup> Then only he concluded it to be the final answer.<sup>87</sup> After this event, the ascetic Gotama claimed that he attained enlightenment. This process can be known from the *Dhammacakkappavattana sutta*, regarded as the first discourse of the Buddha. The passage below illustrates the stage of the “before-enlightenment”:

As long, O Bhikkhus, as the absolute true intuitive knowledge regarding these Four Noble Truths under their three aspects and twelve modes *was not perfectly clear to me, so long I did not acknowledge* in this world inclusive of gods, Māras and Brahmās and amongst the host of ascetics and priests, gods and humans, that I had gained the incomparable supreme enlightenment (*anuttaram sammā-sambodhim*) [Italics mine].<sup>88</sup>

The following passage describes the “after-enlightenment” stage:

When, O Bhikkhus, the absolute true intuitive knowledge regarding these Four Noble Truths under their three aspects and twelve modes *became perfectly clear to me, then only did I acknowledge* in this world inclusive of gods, Māras, Brahmās, amongst the hosts of ascetics and priests, gods and humans, that I had gained the incomparable supreme enlightenment.<sup>89</sup>

The comparison of these two stages demonstrates the shift from the “before” to the “after” of enlightenment.” It should be mentioned that the ascetic Gotama never confirmed to himself that he had gained “the incomparable supreme enlightenment” before his final realization of the completeness of the knowledge. When and only when he perfected knowledge or the theory, he did proclaim himself the supremely awakened Buddha. The Buddha’s discovery of Dhamma means, therefore, that his search and research were finally completed. Dhamma is, in this sense, the discovery that finally proved to be correct after the experiments and re-experiments with many possible hypotheses and theories. The Pāli Nikāya texts recount this event as follows: “I have completed the student life. Done is what was done to be, there is nothing left to do.”<sup>90</sup> The Buddha’s enlightenment means nothing but his conclusive realization.

Hoffman says that a religious doctrine is based upon religious belief and religious unfalsifiability in principle.<sup>91</sup> If so, in Christianity, for example, Christians would probably make propositions as follows regarding God which are unfalsifiable: God is Omnipotent, or, Jesus is God’s Only Son. It seems, in this manner, perhaps, that Karl Barth states in *Church Dogmatics*: “God loves because He loves; because this act is His being, His essence and His nature.”<sup>92</sup> These religious propositions are unfalsifiable.

The Buddhist claim of Dhamma’s validity, however, seems differ from what Hoffman views about a religious doctrine in general. The Early



Buddhists' claim of correctness of Dhamma depends on the completion of a long search and research. Their claim does not rely on the Buddha's authority or superiority. It is vice versa: The ascetic Gotama claimed the supreme Buddhahood in him *after* his accomplishment of the research. And, further if it is the research that led him to the conclusion, the process of the same research should be replicable by others. Indeed, according to the texts, many replicated the same research and arrived at the same conclusion, i.e., they attained Nibbāna.<sup>83</sup> Therefore, Hoffman's idea of religious unfalsifiability in principle is not immediately applicable to the Early Buddhist claim of validity of Dhamma.

## 2. Early Buddhist Position towards The Theory (i.e., Dhamma) As Falsifiable, Which is to be Experimented with and Verified Individually Before It Is Accepted.

In the Pāli Nikāya, one finds Early Buddhists who also claim that any claim of fact or truth should be put to thorough tests and examination to scrutinize such a claim. The aforementioned *Kālāma sutta* is one example of that attitude. In the *Cankī sutta*, too, the Buddha teaches a young brahmin, Kāpātika, not to blindly believe in tradition simply because it had been handed down from generation to generation unbroken. Such a tradition which claims to embody the so called "only Truth" is likened by the Buddha to a "line of blind people" each one clinging on to the preceding one.<sup>84</sup> More interestingly, the *Vimamsaka sutta* declares that the Buddha and his Buddhahood may be put to acid tests. In this sutta, a detailed procedure to scrutinize such claim is laid down.<sup>85</sup> The existence of these suttas in the Nikāya texts itself demonstrates that the Buddha and Early Buddhists established the fact that any theory, including Dhamma, should be taken as falsifiable in principle, before one has tested it for oneself.

Interestingly, a careful study of the Pāli Nikāya texts will also tell us that Dhamma is definitively presented as falsifiable by the Buddha and Early

Buddhists. The definition of Dhamma by the following six characteristics consistently appears throughout the Pāli Nikāya texts. These six characteristics are:

- 1) well-taught or well spoken by the Buddha (*svākkhāto*)
- 2) can be seen in this life itself (*sanditthiko*)
- 3) timeless (*akāliko*)
- 4) inviting investigation (or falsifiable) (*ehipassiko*)
- 5) leading onward (*opaneyiko*)
- 6) to be verified by the wise by and for him/herself (*paccattaṃ veditabbo viññūhi'ti*)<sup>86</sup>

Four out of six of the above characteristics illustrate distinctive aspects of the Early Buddhists' towards their own alleged claim of truth. For example, according to the fourth characteristic, Dhamma invites inspection and examination. The term "*ehipassiko*" definitively characterizes Dhamma's falsifiability. One should not accept Dhamma blindly. Dhamma invites one to come and test it for oneself by means of direct personal knowledge. This also implies that it is always open for anyone to come and test it. Nothing is hidden from public.

According to the sixth characteristic, an inspection of Dhamma is to be done individually, by and for oneself. It indicates that even when inspection is done and the truth is verified by others (even by the Buddha), one still should not readily accept it, because it is not one's direct knowledge. Dhamma should be tested and inspected by oneself, for oneself. For verification of Dhamma or facts, an individual cannot depend on anyone else. Final verification is ultimately by means of personal and direct experience.<sup>87</sup>

The second characteristic, "*sanditthiko*," claims that Dhamma can be seen in this life, which indicates that it deals with reality here and now. Early Buddhism has sometimes in the past and still now been labelled as an amoral, asocial, transcendental, contemplative, and other-world oriented teaching; The distortion of such a notion is demonstrated by reference to this characteristic of Dhamma. Here it should be noted that

realization of Dhamma includes the realization of Nibbāna and it is to be experienced in this life.<sup>98</sup>

The fifth, “*opanayiko*” (leading onward) signifies that the more one inspects Dhamma, the more he/she accepts it, and the more he/she is moved towards the final verification of Dhamma. Inspection, verification and acceptance occur in a gradual, step-by-step process. It is noteworthy that this fifth characteristic is consistent with the Pāli Nikāya’s “teaching method” of a gradual instruction (*anupubbi-kathā*). The Pāli Nikāya texts call their “learning methods” “*anupubba-sikkhā*” (gradual training), “*anupubba-kiriyā*” (gradual doing) and “*anupubba-paṭipadā*” (gradual course).<sup>99</sup> It is interesting that along with these critical characteristics of Dhamma, it is characterized as “*akālika*” (timeless). “*Akālika*” signifies that Dhamma is always timely, relevant to a person and society at all times, verifiable in the past, present, and future. In other words, examination and verification of Dhamma is replicable by any individual regardless of his/her historical, cultural, religious and other backgrounds.

The Early Buddhists’ approach to Dhamma seems distinctively empirical. It invites all comers to verify and test it for themselves, which represents an attitude disposed to seeing its own religious truth.<sup>100</sup>

### 3. Early Buddhist Double Positions

In this way, the Early Buddhists’ attitude towards Dhamma is twofold: On the one hand, they proclaimed Dhamma as explanation of universal law of nature (*dhammatā*), and, on the other hand, they discouraged belief in it and presented it as falsifiable. These two positions appear to be opposing from each other, but are not necessarily contradictory. My perception is that Early Buddhists intentionally adopted these two different approaches, so that the empirical approach to Dhamma could be thoroughly maintained. This approach may be referred to the basic position of “general and healthy scepticism” in science.<sup>101</sup> But, as I will discuss later, in reality, a

scientist has not been rigorously expected to personally and individually replicate every single verification and experiment of others, like Early Buddhists expected to personally and individually replicate every single verification and experiment of Dhamma. Today, as I noted earlier, in modern science, a rigorous experimental testing, not to confirm theories but to refute them, is highly enjoined.<sup>102</sup> This position may be more similar to Early Buddhists’ position: Early Buddhists proclaimed Dhamma as a fact verified by the supremely awakened Buddha (*sammāsambuddha*), and yet, conversely, invited others to treat it as falsifiable, by personally and individually verifying and experimenting it. Namely, one is urged to deal with it as thoroughly skeptically and objectively for and by oneself. Like in science, the only difference between the Buddha or the first scientist who presented the theory and the followers is that the followers’ experiment is much easier and faster, because the first one had already developed all the necessary tools for them.

### V. The Theory (i.e., Dhamma)

In the following, I will discuss the method that the Buddha adopted in arriving at Dhamma as the final theory of truth, by focusing on the principle of Causal Conditionality (*paṭiccasamuppāda*).<sup>103</sup> It is extremely important to note that the theory of *paṭiccasamuppāda* is neither a baseless theory and hypothesis nor the result of revelatory intuition and contemplation, but was obtained through observation of phenomena that *have happened* (*paṭica-samuppanna dhamma*).<sup>104</sup> The theory of *paṭiccasamuppāda* is, technically, formulated based upon “Dependently Co-arisen” phenomena. Kalupahana explains as follows:

The Buddha’s explanation of the nature of existence is summarized in one word, *paṭiccasamuppāda* (Skt. *pratītyasamutpāda*), meaning “dependent arising,” a theory that he formulated on the basis of the experience of dependently arisen phenomena (*paṭicca-*

*samuppanna dhamma*). The meaning of the former is best elucidated by clarifying the implications of the latter . . .

The theory of Causal Conditionality (*paṭiccasamuppāda*), which “has remained valid so far,”<sup>105</sup> is the theory with reference to the past. In the term “*paṭicca-samuppanna dhamma*,” therefore, the past participle tense is used.

According to the Pāli Nikāya texts, an enlightened person thoroughly clarifies and completes two forms of knowledge: “retrospective knowledge” (*anvaye ñāṇaṃ*) and “knowledge of Dhamma” (*dhamme ñāṇaṃ*).<sup>106</sup> “Retrospective knowledge” (*anvaye ñāṇaṃ*) indicates knowledge obtained through direct observation of the phenomena of past events. The method that the Buddha utilized in finding Dhamma’s validity seems adoption of “retrospective knowledge” (*anvaye ñāṇaṃ*). This aspect is noteworthy, for in the field of science, investigation always starts with the direct observation of the phenomena of past events. And it is also interesting that knowledge of phenomena that *have happened* have the potential to become knowledge of phenomena that is happening in the present and will happen in the future. As A. J. Ayer says, one can predict the present and the future only by referring to the past and only when the reference is largely accurate.<sup>107</sup>

“Knowledge of Dhamma” (*dhamme ñāṇaṃ*), another type of knowledge that the Buddha (or an enlightened person) acquired in full, is knowledge of the way things are (Dhamma), which is specifically designated as “knowledge of *paṭiccasamuppāda*.” Dhamma as the theory of Causal Conditionality (*paṭiccasamuppāda*) is knowledge drawn from the past phenomena that have taken place and is formulated as knowledge that is also applicable to present and future. Kalupahana explains as follows:

After explaining all experienced phenomena (*dhamma*) -- and these include conditioned events as well as related ideas or concepts (the latter being

designated by the term *dhamma* in its restricted sense), -- as “dependently arisen” (*paṭiccasamuppanna*), the Buddha formulated a general principle that became the central conception in Buddhism, namely, “dependent arising” (*paṭiccasamuppāda*). In his own words, the principle of dependent arising is an extension of the experience of dependence into the obvious past and the future.<sup>108</sup>

Therefore, the theory of *paṭiccasamuppāda* based upon the “Dependently Co-arisen” phenomena” (*paṭicca-samuppanna dhamma*) becomes the theory of “Dependently Co-arising.” The theory of *paṭiccasamuppāda* is shown by the general formula as follows:

When this is present, that is present;  
From the arising of this, that arises;  
When this is absent, that is absent;  
On the cessation of this, that ceases.<sup>109</sup>

The Early Buddhists’ claim is that the Buddha discovered and thoroughly clarified the knowledge of *paṭiccasamuppāda* and presented it to the world to be used as a definite tool or as a knowledge necessary to solve any problem, although he applied it only to solve the problem of human unhappiness. In this context, Early Buddhism would directly refute a current common assumption that natural and physical science can predict future phenomena, but human science cannot do so, because human beings are totally unpredictable. If this Pāli Nikāya statement is cast in the language of science, we can say that the Buddha predicted future human phenomena through the careful examination of past human phenomena. When this knowledge is established, it should be possible to formulate a highly accurate knowledge of past, present and future, which could be called a Universal Law.<sup>110</sup> The Early Buddhist position is that the universality of the problem of human suffering and the solution of the problem of human suffering is based on the principle of Causal Conditionality

(*paṭiccasamuppāda*). A statement that “the Pāli Nikāya texts are not revelatory texts” does not simply mean that the Pāli Nikāyas do not reveal any new knowledge that was previously unavailable to us.

In the process of examining the nature of human suffering, the principle of *paṭiccasamuppāda* is applied to the realm of ethics.<sup>111</sup> Some examples of the Buddha’s statements relevant to the above concern in Nikāyas texts are as follows:

It is impossible, monks, it cannot come to pass, that the fruit of an action ill done by body, speech and mind should be pleasant, dear, delightful. But that it should be quite otherwise is possible.

It is impossible, monks, it cannot come to pass, that the fruit of an action well done by body, speech and mind should be unpleasant, hateful, distasteful. But that it should be otherwise is quite possible.<sup>112</sup>

According to the first part of the statement of each passage, it is impossible that a negative (or positive) action of the body, speech, and thought generates a positive (or negative) result, since the major cause that brings a positive (or negative) result is not there. But, according to the latter part of each statement mentions, it is possible that a negative action generates a negative result, or a positive action generates a positive result. The major cause (*hetu*) by itself is not enough to bring the necessary effect. Other supportive conditions (*paccaya*) must be present. This means it is also possible that one may not receive the negative (or positive) effect of one’s negative (or positive) action depending on other supportive conditions.

It is noteworthy that elsewhere the Buddha explains the latter part of the above each message by the same causal moral principle, utilizing a metaphor from a simple knowledge of natural science: A little cup of water becomes salty due to a grain of salt, but it is possible that the river Ganges may not become salty due to a grain of salt because of great mass of water in the river.<sup>113</sup> By the metaphor of the water and the grain of salt, the

Buddha points out how someone who engages in verbal, physical or mental negative action may not experience the negative effect of the action. The salt here indicates the primary cause and condition, and the quantity of water the supportive conditions. The intensity of the negative or positive effect of negative or positive action is varied depending on supportive conditions related to the situation. But, the principle of Causal Conditionality (*paṭiccasamuppāda*) adopted to the first part of the above statement clearly stipulates that it is impossible that both the water in a little cup and a great mass water in the river Ganges become sweet due to the grain of salt.

The principle of Causal Conditionality (*paṭiccasamuppāda*) stipulates that when and only when all the necessary set of causes and conditions come together, whenever and wherever, there will necessarily be the same effect. The Pāli Nikāya categorically defines the principle as the four characteristics: (1) “objectivity” (*tathatā*); (2) “necessity” (*avithatā*); (3) “invariability” (*anaññathatā*); and (4) “conditionality” (*idappaccayatā*).<sup>114</sup> The principle of *paṭiccasamuppāda* is not as simple and plain as one may think. According to the texts, Ānanda, the chief attendant of the Buddha, understanding the principle of causal conditionality (*paṭiccasamuppāda*) perhaps only partially, said to the Buddha, “to me it seems as clear as clear can be!”<sup>115</sup> The Buddha corrected him by telling him the depth and complexity of the theory as follows:

Say not so, Ānanda, say not so! Deep is this doctrine of events as arising from causes, and it looks deep too. It is through not understanding this doctrine, through not penetrating it, that this generation has become a tangled skein, a matted ball of thread, like to munja-grass and rushes, unable to overpass the doom of the Waste, the Woeful Way, the Downfall, the Constant Round [of Re-existence].<sup>116</sup>

As we discussed earlier, Early Buddhists adopted

some distinctive methods in establishing the truth claim of Dhamma: (1) The theory starts with direct observation of phenomenon; (2) the theory is based on the retrospective recollection of already experienced phenomena; and (3) the theory is the present and future causal conditionality. In their adoption of the methodologies, Early Buddhists are apparently asserting two claims regarding the nature of Dhamma: (1) Dhamma is universally true and (2) Dhamma is empirical. One may conclude that the Early Buddhists claim for the justification of the universal validity of Dhamma is not based upon a religious or tautological justification.

#### V. Difference between Proof and Verification

Empirical verification of the theory (Dhamma) is one of the major issues in Early Buddhism. In the following discussion, I will attempt to clarify the Buddhist meaning of "verification." In doing so, a distinction between the terms "verify" and "prove" may be helpful, although they are generally used synonymously. In this discussion, I use the term "verify" when a theory is based on retrospective knowledge and thus empirical verification is possible, and use the term "prove" when a theory is not based on retrospective knowledge and thus empirical verification is not possible.

A theory of probability or prediction, based upon past existing phenomena, is verifiable either as true or untrue by experiment. When testing does not confirm the theory, it has been falsified or verified to be untrue. Conversely, a theory that is not based on past phenomena, such as revelation or prophesy, is not verifiable, but provable to be either true or untrue by logic or reason.<sup>117</sup> It can never be falsified, for in this case falsification is not the issue. Even if revelation or prophesy is not proved as it claims, it does not mean that prophesy or revelation is falsified. Prophesy and probability are fundamentally different. For example, when the theory states, "when self-centeredness (*taṇhā*) is absent, suffering (*dukkha*) is absent," the theory is falsifiable and subject to "verification." On the other hand, a

christological doctrine of the Trinity, for example, that stipulates that Jesus Christ is God's Only Son (John 1. 14 in the New Testament) is unfalsifiable and not subject to "verification." This doctrine has no potential to be verified, being not based upon retrospective knowledge.

The issue of unfalsifiability applies only to probability or prediction which is based on the knowledge of the past, but not prophecy. Indeed, Hoffman believes that in the religious context there is no distinction between "prophecy" and "prediction."<sup>118</sup> By identifying at least two different type of theories, Hoffman arrived at his conclusion that religions are unfalsifiable in principle. But, as I have argued, one cannot conclude that Christianity and Early Buddhism are unfalsifiable in principle and science is falsifiable in principle. When the theory is formulated impersonally, the existence of the person who discovered the theory (or the Buddha) or belief or faith in the theory (or Dhamma) are essentially unnecessary. By making a simplistic comparison of Christianity and Early Buddhism, he comes to the general conclusion that they are similar as religions. Dhamma is based on retrospective knowledge, thus, falsifiable; it requires experiment, observation, verification and replication.

#### 2. Experimentation and Verification are Private and Personal both in Science and Buddhism

The theory of Causal Conditionality (*paṭiccasamuppāda*) is the theory of the causal and conditional relationship between of "this" and "that," which can be known and verified only by direct observation. It is empirical by nature, signifying that it bears no truth unless it is confirmed through observation. When one personally and directly experiences the causal relationship of "this" and "that," one can make use of this knowledge to eliminate the undesirable effects of things or to generate desired effects. Hence, Dhamma or *paṭiccasamuppāda* is known only by the wise (*viññū*), because the wise, by utilizing the knowledge of causal relationship, makes

positive changes in his/her life.

Several questions can be raised regarding the meaning of verification of Dhamma. How can a person who is not enlightened empirically verify Nibbāna, the very final stage of cessation of self-centeredness (*taṇhā*) and thereby cessation of suffering (*dukkha*)? Or more directly, is Nibbāna falsifiable? Indeed, unless one takes the necessary steps for final verification, one can neither empirically experiment nor fully verify it. However, it does not mean that Nibbāna is unfalsifiable. Verification of Nibbāna may not be easy, but the issue of ease or difficulty of falsifiability is different from the issue of its possibility. As I have already mentioned, experience and verification of Dhamma is a gradual progression. The theory of *paṭiccasamuppāda* stipulates that reduction (or promotion) of self-centeredness (*taṇhā*) and reduction (or promotion) of suffering (*dukkha*) occur proportionately and simultaneously: When *taṇhā* (self-centeredness) is reduced (or increased) to a certain degree, *dukkha* (suffering) is also reduced (or increased) in the same proportion. A person can empirically experience and verify a gradual reduction of self-centeredness (*taṇhā*) and thereby a gradual reduction (or promotion) of suffering (*dukkha*) depending on his/her different level of mental development. The more agreement he/she finds between the experience and the theory, the more confidence in the hypothesis (theory) and enthusiasm to continue further research increases.

According to Early Buddhism, both self-centeredness (*taṇhā*) and suffering (*dukkha*) are one's mental activities. A person can observe or become aware of these mental activities by obtaining proper tools for this observation. Early Buddhists taught that one of the major tools can be obtained by the development of the mental faculty of mindfulness (*sati*).<sup>119</sup> Another tool which helps to cultivate one's direct observation is the development of the mental faculty of calmness (*samādhi*). Early Buddhism also teaches that the cultivation of calmness (*samādhi*) and insight

(*paññā*) is integrally linked with the cultivation of virtue or ethical conduct (*sīla*). Thus, ethical conduct (*sīla*), concentration (*samādhi*) and insight (*paññā*) are regarded as the three fields of training which develop integrally, simultaneously and proportionately. By the cultivation of these three, regardless of one's religious affiliation, one can perceive one's own reduction of self-centeredness (*taṇhā*) and thereby the reduction of suffering (*dukkha*) by and for oneself.

The Early Buddhist position is that no one can experience or verify Dhamma for others. Experience and verification cannot be shared with others, but the method and other information about the experience can be shared with others. "Public experience" and "public verification" would be a contradiction in terms for Early Buddhists. As Henry Cruise states, "knowledge" is a private thing for Early Buddhists and "public knowledge" would be a contradiction in terms.<sup>120</sup> Experience or verification does not count unless one has personally experienced or verified something by and for oneself.

According to the text, however, it is possible that another can recognize that a person has perfectly cultivated morality (*sīlavā*) or a person has perfectly cultivated wisdom (*paññāvā*), through an association "after a long time, not casually, by close attention, not by inattention, by a wise person, not by one weak in wisdom."<sup>121</sup> If so, it must be also possible that through a long, careful and close association, a wise person can recognize the other who had experienced or verified some special knowledge and gained personal understanding.

Modern Western hermeneutics attempt to establish a so called "objective" and "scientific" interpretation of the literary texts. The underlying assumption is that information in natural science is "objective," as opposed to information in the humanities. Such an assumption generates several interesting questions. In natural science, a scientist's experiment or verification proceeds by means of repetition and objective measurements. These measurements enable a scientist to quantify

the results of the experiment and supports verification by imparting statistical credibility. Quantification leads modern society to hold several illusions about scientific theories. First, although the public at large may think that scientific data is “accurate,” present technology does not allow scientific data to be “accurate.” All numbers obtained in an experiment have only a relative degree of precision. Numbers used in science are human expression of phenomena, but not the phenomena themselves. Therefore, scientific data is not “accurate,” “factual” or “objective.” Secondly, due to the current advancement of the mass media, scientific information is publicized and shared, and thus regarded as “the property not of individuals but of the entire human race.”<sup>122</sup> Therefore, it is unconsciously believed that verification or experiment itself is public and can be shared. Scientists rely on the “verification” of others’ replications of experiments so that each scientist does not have to repeat each experiment, but can build on the work of others to test new propositions. A scientist is allowed to accept other scientists’ scientific experiment, measurement, theories, law, or applications without he/she him/herself repeating the same actual scientific practices, once he/she can take them for granted. Thus, he/she does not have to start from first principles and justify the use of each concept introduced.<sup>123</sup>

But, from an Early Buddhist perspective, other than the person who did the actual experiment, everyone else is only believing what others verified. For others, all the data provided by the scientist is merely hearsay. In other words, direct experience of experiment or verification, whether scientific or Buddhist, is essentially private and personal.<sup>124</sup> One may safely state that the Early Buddhist approach to Dhamma and other theories seems even more thoroughly empirical than the scientists’ approach to their theories.

In the fields of science, the number of research objects are incomparably enormous. Each branch of science has grown so fast, and become so complex, “that even experts had to rely on libraries,

assistants and *aidesmēmoires* even in their own fields.”<sup>125</sup> Scientists have perforce to omit individual experiments and verifications; not only is life too short to do a personal verification for each theory on the innumerable objects or subject matters in the physical world, but it is also impossible due to the technical difficulties of experiments and verification. In science, sharing information is sometimes tantamount to sharing experiments and verification. Scientists seek to move on to new hypotheses, adding, changing and revising old theories.

In case of Buddhism, on the other hand, as I will discuss next, world or universe is defined by the eighteen components, therefore, there are no more than eighteen fields to study. The Buddha and many others fulfilled the final goal by realizing these eighteen elements. Thus, unlike scientists, Buddhists seek to verify the same Dhamma.

Unfortunately, with current technology, it is not possible to fully demonstrate the action of mind by numbers.<sup>126</sup> No one can yet determine the intensity or the degree of self-centeredness (*taṇhā*), suffering (*dukkha*) by “objective” measurement. Therefore, it is often believed that experience gained through Buddhist meditation is personal and private, while experience gained through modern science is public. From here, it may also be believed that the meanings of “verification” in Buddhism and in science are different. But, from the Early Buddhists’ point of view, these assumptions are one-sided. Even if quantification of the intensities of mental activities becomes possible, numbers themselves are only conventional and symbolic and are not activities themselves. This is why Early Buddhists enjoin replication of individual participation in each level of experience of Dhamma. Narratives of Pāli Nikāya texts tell us that Dhamma was enjoyed not only by adults, but also by children.<sup>127</sup> Early Buddhists did not advocate the treatment of Dhamma as religious and spiritual dogma which should be accepted without verification. It is reasonable to conclude that Early Buddhism requires radical empiricism.

## V. Objects of Research

A major difference between Early Buddhism and science is the number of their research object. During the past few decades, due to new discoveries and consequent revision of old information, data in the fields of science have proliferated. Science will continuously keep searching for answers, and therefore keep revising and correcting old information. In science, the number of questions to be answered is literally innumerable, because the universe they are researching is "infinite." It is interesting that, according to Geoffrey Redmond, some scientists undoubtedly believe that science eventually will become capable of explaining everything, while others undoubtedly do not.<sup>128</sup>

In Buddhism, on the other hand, the number of questions to be answered is definitively minimized by condensing the entire universe to only eighteen fields of study. In the Early Buddhist understanding, the questions that were set to be answered were completely answered by the complete examination of these eighteen fields. They claim that using this approach all the questions that must be answered to understand the world or universe were completely answered by the Buddha and thousands of his disciples about 2600 years ago. Buddhism observes that the world is constituted by eighteen objects. The following is the definition of the universe, the whole world or what we call "everything." Once one knows how they operate together, he/she is regarded as a person who understood the universe, the whole world, or everything, called "*sabbāññu*"<sup>129</sup> meaning one who knows everything or "*lokavidu*"<sup>130</sup> meaning one who knows the whole world.

Universe / Whole World / Everything		
eye	+ visual object	+ visual consciousness
ear	+ auditory object	+ auditory consciousness
nose	+ olfactory object	+ olfactory consciousness
tongue	+ gustatory object	+ gustatory consciousness
skin	+ tangible objects	+ tactile consciousness
mind	+ mental objects (concepts)	+ mental consciousness <sup>131</sup>

In Buddhism, unlike science, each sensory object, such as "form," for example, represents

all the forms that eyes perceive. In other words, Buddhism would not attempt to examine each particular form one by one as in science. Buddhism does not attempt to examine the "form" of one molecule or the "form" of the planet Saturn. In "form," all forms as visual objects are encompassed. Buddhism emphasizes the quest of examining how the sensory organs and sensory objects operate together to generate the sensory consciousness that form the sensory world, which we call whole universe.<sup>132</sup> Thus, Buddhism completes the full examination of the interaction of these eighteen spheres that make up the whole universe, which can be fully understood with systematic and thorough examination in a limited amount of time. Early Buddhist research, from ethics to cosmology, is solely directed to understand the normal or abnormal interaction of these eighteen fields which finally becomes a matter of mind. Since the Buddha and many others verified that suffering (*dukkha*), an abnormal interaction of these eighteen factors, can be completely eliminated by fully understanding and realizing them, for Buddhists, it is virtually unnecessary to move on to new hypotheses or explore more numbers of new fields. But, the methodology that Early Buddhism adopted in this search is similar to the methodology that scientists adopt in their search.

## VI. Conclusion

Buddhism is conventionally categorized as "religion," but Early Buddhists would virtually disagree with this characterization. Also, Early Buddhism (and perhaps Buddhism in general) is often categorized as "atheistic" or "non-theistic."<sup>133</sup> But, as a matter of fact, such a notion is irrelevant to Early Buddhism (and also perhaps Buddhism in general), just as it is irrelevant to natural sciences: No one would ask, whether chemistry, for example, is "theistic" or "atheistic." If Buddhism is categorized under the rubric of religion, what is needed is a definition of religion which is not solely based on its theistic forms.



The Early Buddhists' approach to their own alleged truth also seems to directly challenge modern scholars' current Western hermeneutics. Originating with a pivotal concern of a Christian theologian, F. D. E. Schleiermacher (1768-1834), modern Western hermeneutics has grown into a prominent movement that involves the entire arena of modern intellectual disciplines. Today, it is considered that among modern intellectual disciplines, "the problems of hermeneutics are more unavoidable in the scholarly study of religion than in many other academic disciplines."<sup>134</sup> Scholars of modern Western hermeneutics regard the study of religion as an "interpretation of an interpretation."<sup>135</sup> It may be right as long as it is referring to a belief system of a theological religion whose system is reliant on the faith of certain communities with certain interpretations. In such a religious system, hermeneutics, in the sense of the theories and principles of interpretations, play a crucially important role. But, the above notion of religion is derived from Western religions and does not seem immediately applicable to the system of Early Buddhism, though it is conventionally called religion.

In this essay, I have attempted to show that in the search for truth Early Buddhism adopts a thorough empiricism, based upon direct observation, retrospective knowledge of past experiences, experiment, verification or realization, and replication, all of which methodologies of research are similar to science. From the beginning to the end, Dhamma is presented not only falsifiable but also to be individually and personally tested and examined before one fully accepts it.

Some, perhaps some Buddhists who see Buddhism as a "religion," might think that to see Buddhism as a scientific search would devalue and diminish Buddhism, claiming that Buddhism has much deeper elements than science or that Buddhism teaches more than science does. Buddhism is not diminished by being likened to science in the methodologies it adopts. The Buddha himself declared that he did not communicate all the knowledge that he acquired.<sup>136</sup> He clearly limited

himself to teach only the knowledge that leads to ending of suffering,<sup>137</sup> which is the normalization of the interaction of eighteen components of universe. One can/should not casually speculate that the value of religion should be higher than that of science. While admitting that both religion and science have yielded tremendous benefits, one must acknowledge the disastrous products of both through the course of history. In the name of religion, religious institutions and ostensibly religious thought (dogma), their followers have literally destroyed and killed people, justifying their atrocities by invoking specious and sanctimonious principles. Scientific discoveries and technologies have also been responsible for similar results by governments producing and using nuclear bombs and other weapons, for example.

The question is: How can knowledge, whether it be so called religious and theological doctrines allegedly claimed as truth, or so called scientific knowledge, be utilized for the benefit of human and other beings? Knowledge can be misused by human beings whenever they are driven by self-centeredness (*taṇhā*), which is a result of abnormal interaction of eighteen components of universe. By the misuse of knowledge, destruction, damage, and harm to many beings can result. Science and religion need to continuously examine themselves in the application of knowledge in the real world. This is why Early Buddhists warned against a mishandling of Dhamma in the parable of the snake. And this is why Early Buddhists consistently enjoined the adoption of a thorough and personal empirical examination and verification of Dhamma by and through oneself.

According to contemporary science, it is not possible any more to make a distinction between the body and the mind, the physical world and the mental world. A separation between science and ethics then also becomes eventually impossible. But, in the meantime, the scientist and ethicist can attempt to see the unity of science and ethics. Indeed, modern scientific technologies are urging them to do so.

We already see a positive sign for it in science: A contemporary American physicist, Michio Kaku's simple proclamation that "science and technology should not be used to harm anyone"<sup>138</sup> is a healthy statement that a modern scientist can make, stepping forward towards a formation of wholesome science where ethics ("ought") and science ("is") are embodied together. Perhaps, the notion of "health" in the field of medical (and dental) science also further promotes the possibility of considering a unity of knowledge of scientific methods and knowledge of ethical decision making: Dental/medical professionals try to use the knowledge to change human behavior in order to protect them from illnesses, prevent and cure illnesses and to provide physical/oral health. It is noteworthy that, as we have seen, the Early Buddhist moral system is the descriptive structure of "is," in which "ought" is automatically embodied and established.

Early Buddhists would claim that their moral system is not a certain "religious" (in this case "Buddhist") moral system. They would disagree to regard it "Buddhist ethics." They would see the moral system based upon the principle of Causal Conditionality (*paṭiccasamuppāda*) as a "universal moral system" which is based upon thoroughly and individually empirical, falsifiable, and replicable methodologies and approaches, but not upon a religious and theological dogma and belief. They enjoin to neither accept nor believe Dhamma, but personally experience and verify it.

When knowledge and human behavior are harmoniously combined, ethics and science will be unified, thereby science itself can be made essentially a part of ethical research. Some 2600 years ago, Early Buddhists esteemed the Buddha not only as the ultimate Surgeon General (*sallakatto anuttaro*),<sup>139</sup> but also as the one who modeled behavior after knowledge (*vijjā-caraṇa-sampanno*).<sup>140</sup> Today, it is noteworthy that Early Buddhists called their own search or quest "noble investigation/research (*ariyapariyesanā*)."<sup>141</sup> For them, Buddha-Dhamma is ethics based upon

scientific discipline or science in which ethics is embodied, of which sole purpose is the enhancement of the quality of life.

#### ABBREVIATIONS:

<i>A</i>	<i>Aṅguttara Nikāya</i>
<i>D</i>	<i>Dīgha Nikāya</i>
<i>Dh</i>	<i>Dhammapada</i>
<i>M</i>	<i>Majjhima Nikāya</i>
<i>S</i>	<i>Samyutta Nikāya</i>
<i>Sn</i>	<i>Suttānipāta</i>

#### BIBLIOGRAPHY:

A. Original Sources: Pāli Texts and Translations *Aṅguttara Nikāya*, 5 Vols., R. Morris and E. Hardy (eds.), The Pāli Text Society, London, 1885-1900.

*Dhammapada*, S. Radhakrishnan (trans.), Oxford University Press, Oxford, 1966.

*Dīgha Nikāya*, 3 Vols., T. W. Rhys Davids and J. E. Carpenter (eds.), The Pāli Text Society, London, 1899-1921.

*Majjhima Nikāya*, 3 Vols., V. Trenkner and R. Chalmers (eds.), The Pāli Text Society, London, 1948-1951.

*Samyutta Nikāya*, 6 Vols., L. Feer (ed.), The Pāli Text Society, London, 1884-1904.

*Suttānipāta*, H. Saddhatissa (trans.), Curzon Press Ltd., London, 1985.

*The Book of the Discipline* (Vinaya-Piṭaka), 6 vols., I. B. Horner (trans.), The Pāli Text Society, London, 1975-1986.

#### B. Secondary Sources

*Encyclopedia of Philosophy*, 8 Vols., P. Edwards (ed.), Macmillan Publishing Co., Inc. & The Free Press, New York, 1967.

*Encyclopedia of Religion*, 16 Vols., M. Eliade (ed.), Macmillan Publishing Co., Inc. & The Free Press, New York, 1987.

*Encyclopedia of Religion and Ethics*, 13 Vols., J. Hastings (ed.), Charles Scribner's Sons, 1908-1926.

*Hutchinson Dictionary of Ideas*, O. Adikibi (ed.), ABC-Clio, Santa Barbara, 1994.

*Key Ideas in Human Thought*, K. Mcleish (ed.),

Facts On File, Inc., New York, 1993.

*Pāli-English Dictionary*, T. W. Rhys Davids and W. Stede (eds.), The Pāli Text Society, London, 1979.

(II) Monographs, Articles, Anthologies and Presentations  
赤沼智善. 『原始仏教の研究』, 京都: 法蔵館, 1981.

Ayer, Alfred Jules. *Language, Truth and Logic*. New York: Dover Publications, 1952.

Barth, Karl. *Church Dogmatics*, edited by G. W. Bromiley and T. F. Torrance and translated by T. H. L. Parker, W. B. Johnson, Harold Knight, and J. L. M. Harire. Edinburgh: T & T Clark, 1964.

Bond, George. "The Gradual Path as a Hermeneutical Approach to the Dhamma." In *Buddhist Hermeneutics*. Edited by Donald S. Lopez, Jr. Honolulu: University of Hawaii Press, 1988.

\_\_\_\_\_. *The Word of the Buddha*. Colombo: M. D. Gunasena & Co. Ltd., 1982.

Capra, Fritjof. *The Tao of Physics*. Colorado: Bantam Books, 1977.

Carter, John Ross. "Dhamma as a Religious Concept: A Brief Investigation of its History in the Western Academic Tradition and Its Centrality within the Sinhalese Theravāda Tradition." *Journal of the American Academy of Religion* 44 (1976): 661-679.

Cruise, Henry. "Early Buddhism: Some Recent Misconceptions." *Philosophy East and West* 33 (1983): 149-166.

Dharmasiri, Gunapala. *Fundamentals of Buddhist Ethics*. Antiock: Golden Leaves Publishing Company, 1989.

Frankena, William. *Ethics*. New Jersey: Prentice-Hall, Inc., 1973.

Gregory, Peter. "Chinese Buddhist hermeneutics: The Case of Hua-yen." *Journal of the American Academy of Religion* 51 (1983): 231-249.

Griffiths, Paul J. "Notes towards a critique of Buddhist karmic theory." *Religious Studies* 18 (1982): 277-291.

Hoffman, Frank. "Buddhist Belief 'In'." *Religious Studies* 21 (1985): 381-387.

\_\_\_\_\_. *Rationality and Mind in Early Buddhism*. Delhi: Motilal Banarsidass, 1987.

\_\_\_\_\_. "The Buddhist Empiricism Thesis." *Religious Studies* 18 (1982): 151-158.

Jayatilleke, K. N. *Early Buddhist Theory of Knowledge*. London: George Allen & Unwin Ltd., 1963.

Kaku, Michio. "The Harmony Between Modern Science and Religion: The New Unification in Physics." Key-note speech at the Buddhist Churches of America Ministers Association and National Council Meeting Banquet, Palo Alto, California, February 1995.

Kalupahana, David. *A History of Buddhist Philosophy*. Honolulu: University of Hawaii Press, 1992.

\_\_\_\_\_. *Buddhist Philosophy: A Historical Analysis*. Honolulu: University of Hawaii Press, 1976.

\_\_\_\_\_. *Causality: The Central Philosophy of Buddhism*. Honolulu: University of Hawaii Press, 1975.

Katz, Nathan. *Buddhist Images of Human Perfection*. Delhi: Motilal Banarsidass, 1982.

Kuhn, Thomas S. *The Structure of Scientific Revolution*. Chicago: The University of Chicago Press, 1970.

MacIntyre, Alasdair. *A Short History of Ethics*. New York: The Macmillan Company, 1966.

中村 元. 『原始仏教の成立』. 東京: 春秋社, 1992.

中村 元&三枝充慎. 『パウツダ』. 東京: 小学館, 1987.

Reat, N. Ross. "Pluralism, Deconstructionism, and World Theology." Presentation at AAR Congress, Chicago, 1994.

Redmond, Geoffrey P. "Science and Buddhism: A Critical Review." Presentation at Taiwan Conference, Taipei, 1994.

三枝充慎. 『初期仏教の思想』. 東京: 東洋哲学研究所, 1978.

Taniguchi, Shoyo. "Methodology of Buddhist Biomedical Ethics." In *Religious Methods and Resources in Bioethics*, edited by Paul F. Camenisch.

Dordrecht, Boston and London: Kluwer Academic Publishers), 1994.

Thurman, Robert. "Buddhist Hermeneutics." *Journal of American Academy of Religion* 46 (1978): 19-39.

White, J. E. "Is Buddhist Karmic Theory False?" *Religious Studies* 19, (1983): 223-228.

#### REFERENCES:

- 1 I extend my great appreciation to the Venerable Madawala Seelawimala, Professor of the Institute of Buddhist Studies and the Graduate Theological Union, Dr. Geoffrey P. Redmond, President of Foundation for Developmental Endocrinology, Inc., and Dr. Clarence Hisatsune, Professor Emeritus, Pennsylvania State University, for their ideas and suggestions for this essay.
- 2 *Encyclopaedia of Religion and Ethics*, 1951 ed., s.v. "ethics" by J. H. Muirhead
- 3 See also *The Encyclopedia of Philosophy*, Vol.3. 1967 ed., s.v., "History of Ethics," by Raziel Abelson, "Problems of Ethics," by Kai Nielsen.
- 4 Cf. Alasdair MacIntyre, *A Short History of Ethics*; William K. Frankena, *Ethics*; Fritiof Capra, *The Tao of Physics*.
- 5 Frankena, *Ethics*, pp.5-11.
- 6 I use the term "Early Buddhists" in the sense of those who lived at the very early stage of Buddhism in India and utilized Dhamma, depicted in the Pāli Nikāya texts as available today, as their fundamental source of knowledge.
- 7 E. g., David Kalupahana, *A History of Buddhist Philosophy: Continuities and Discontinuities*; Kalupahana, *Buddhist Philosophy: A Historical Analysis*; Kalupahana, *Causality: The Central Philosophy of Buddhism*; K. N. Jayatilleke, *Early Buddhist Theory of Knowledge*.
- 8 E. g., Frank J. Hoffman, *Rationality and Mind in Early Buddhism*; Hoffman, "Buddhist Belief 'In'," *Religious Studies* 21, (1985): 381-387; J. E. White, "Is Buddhist Karmic Theory False?" *Religious Studies* 19, No.2 (June 1983): 223-228; Paul J. Griffiths, "Notes towards a critique of Buddhist karmic theory," *Religious Studies* 18, No.3 (September 1982): 277-291; Henry Cruise, "Early Buddhism: Some recent misconceptions," *Philosophy East and West* 33, No.2 (April 1983): 149-166; Hoffman, "The Buddhist Empiricism Thesis," *Religious Studies* 18, No.3 (1982): 151-158.
- 9 *Key Ideas in Human Thought*, Kenneth McLeish, ed., s.v., "science."
- 10 *The Hutchinson Dictionary of Ideas*, ed., Owen Adikibi, s.v., "science."
- 11 *The Encyclopedia of Philosophy*, Vol.7. 1967 ed., s.v., "Scientific Method" by Peter Caws.
- 12 *Key Ideas in Human Thought*, ed., Kenneth McLeish, p.657.
- 13 Kuhn, *The Structure of Scientific Revolutions*, p.209.
- 14 *Key Ideas in Human Thought*, ed., Kenneth McLeish, s.v., "science."
- 15 *The Hutchinson Dictionary of Ideas*, ed., Owen Adikibi, s.v., "science."
- 16 *The Book of the Discipline*, Vol. V (*Cullavagga*), pp.193-194.
- 17 E.g., S. I. 71-74.
- 18 Traditionally, it is said that "me" refers to Ānanda, the Buddha's closest attending disciple who served him for the last 25 years of the Buddha's life. He is said to have listened to and memorized the Buddha's teachings more fully than any other disciples. Ānanda, because of his distinctive memory, is said to have been assigned the task of redaction of the Pāli Nikāya texts.
- 19 In the later Mahāyāna literature, however, the same stock phrase is rather used in the sense of the direct teaching of the Buddha himself.
- 20 Peter Gregory, "Chinese Buddhist hermeneutics: The Case of Hua-yen," *Journal of the American Academy of Religion* 51, Nov.2 (June 1983): 232.
- 21 They are as follows: Something is the truth, the law, the teaching of the Master, when it is: (i) "from the mouth of the Exalted One himself

- heard by me, from his own mouth it is received by me." (ii) "In such and such a dwelling-place there is a company of the disciples with their elders and leaders. From the mouth of that company heard by me, face to face is received by me." (iii) "In such a such a dwelling-place there are dwelling many elders of the Order, deeply read, holding the faith as handed down by tradition, versed in the truths, versed in the regulations of the Order, versed in the summaries of the doctrines and the law. From the mouth of those elders heard by me, from their mouth has been received by me." (iv) "In such a such a dwelling-place, there lives a disciple, deeply read, holding the faith as handed down by tradition, versed in the truths, versed in the regulations of the Order, versed in the summaries of the doctrines and the law. From the mouth of that leader has been heard by me, from his[sic] mouth has been received by me." When a teaching is received in the presence of one of these four, a person might represent it as authoritative and authentic by saying, "This is Dhamma, this is the law, this is the teaching of the Master." *D.* II. 123-124.
- 22 E.g., *A.* I. 157.
- 23 *M.* III. 24-29.
- 24 *A.* II. 51.
- 25 Gregory, "Chinese Buddhist hermeneutics: The Case of Hua-yen," *Journal of the American Academy of Religion* 51, No.2 (June 1983): 232.
- 26 *Ibid.*
- 27 See Shoyo Taniguchi, "Methodology of Buddhist Biomedical Ethics," in *Religious Methods and Resources in Bioethics*, ed., Paul F. Camenisch, pp.37-42.
- 28 By "belief" I mean baseless belief or blind belief. I do not indicate the notion of "saddhā" or "confidence" in Early Buddhism here.
- 29 *A.* I. 187.
- 30 Following the definition of the *Encyclopedia of Philosophy*, I use the term "empiricism" in the sense of "the theory that experience rather than reason is the source of knowledge, and in this sense it is opposed to rationalism." See *The Encyclopedia of Philosophy*, 1967 ed., s.v. "Empiricism" by D. W. Hamlyn.
- 31 K. N. Jayatilleke, *Early Buddhist Theory of Knowledge*, p.272.
- 32 *Ibid.*, p.328.
- 33 *S.* II. 105.
- 34 *Ibid.* As I discuss later, due to the nature of Dhamma, this discovery should be differentiated from so called "revelation" used in the theology.
- 35 *S.* II. 25.
- 36 *Encyclopedia of Religion*, 1987 ed., s.v. "Buddhist Literature: Exegesis and Hermeneutics," by L. Gomez.
- 37 Frank J. Hoffman, *Rationality and Mind in Early Buddhism*, p.6.
- 38 *Ibid.*, p.6.
- 39 Nathan Katz, *Buddhist Images of Human Perfection*, pp.122-145.
- 40 中村元, 【原始仏教の成立】, pp.201-202. This is also the case in Jainism.
- 41 Robert Thurman, "Buddhist Hermeneutics," *Journal of the American Academy of Religion* 46, No.1 (March 1978): 20.
- 42 *M.* I. 130-142.
- 43 *Ibid.*
- 44 三枝充憲, 【初期仏教の思想】, p.187.
- 45 *D.* I. 178-189; *M.* I. 426-432. Cf. David Kalupahana, *Causality: The Central Philosophy of Buddhism*, p.178.
- 46 Kalupahana, *Causality: The Central Philosophy of Buddhism*, pp.177-183. The present essay does not discuss extra-sensory knowledge or trans-empirical knowledge, that goes beyond the realm of empiricism.
- 47 Jayatilleke, *Early Buddhist Theory of Knowledge*, p.475.
- 48 Kalupahana, *Causality: The Central Philosophy of Buddhism*, p.180.
- 49 *Encyclopaedia of Religion and Ethics*, 1951 ed., s.v., "Science" by J. Arthur Thomson.
- 50 *S.* V. 353-354.
- 51 Cf. Kalupahana, *Causality: The Central Philosophy of Buddhism*; 赤沼智善, 【原始仏教の研究】, pp.29-34.

- 52 中村元&三枝充恵, [パウツダ], p.149.
- 53 A. I. 156-157.
- 54 S. V. 421; D. II. 61; D. II. 308; D. III. 216; D. III. 275; S. III. 26; S. III. 158; *It*50, etc.
- 55 S. V. 75.
- 56 *Dh.* 129, 130.
- 57 S. V. 437.
- 58 Gunapala Dharmasiri, *Fundamentals of Buddhist Ethics*, p.25.
- 59 *Ibid.*, p.26.
- 60 *Ibid.*
- 61 E.g., *Dh.* 129, 130.
- 62 *Theragāthā*, 12; *Sn.* 212, 782, 790, 797, 803; *It.* 79.
- 63 Hoffman, *Rationality and Mind in Early Buddhism*, p.33.
- 64 *Ibid.*, pp.33-43.
- 65 E.g., S. V. 420.
- 66 Hoffman, *Rationality and Mind in Early Buddhism*, p.33.
- 67 *Ibid.*
- 68 *Ibid.*
- 69 Hoffman, *Rationality and Mind in Early Buddhism*, p.42-43.
- 70 See Taniguchi, "Methodology of Buddhist Biomedical Ethics," pp.38-42.
- 71 E.g., Vinayapīṭaka, *Mahāvagga*, I. 6, 14; *The Book of the Discipline* Vol. IV. p.23, 24, 26., 27, 32, etc., Vol. II. 156, 192; D. I. 110; D. II. 41; M. I. 379; J. I. 8; *Mil.* 228.
- 72 M. III. 258-215.
- 73 Magdalene and Wilhelm Geiger, *Pāli Dhamma: vornehmlich in der kanonischen Literatur*, (Abhandlungen der Bayerischen Akademie der Wissenschaften; Philosophisch -- philologische und historische Klasse; Munchen; Verlag der Bayerischen Akademie der Wissenschaften, 1920) Band 1,3. quoted in John Ross Carter, "Dhamma as a Religious Concept: A Brief Investigation of its History in the Western Academic Tradition and Its Centrality within the Sinhalese Theravāda Tradition," *Journal of the American Academy of Religion* 44, No.1 (March, 1976): 661-665.
- 74 See Carter, "Dhamma as a Religious Concept," 661-665.
- 75 *Ibid.*, 666.
- 76 See Carter, "Dhamma as a Religious Concept," 661-674.
- 77 Hoffman, *Rationality and Mind in Early Buddhism*, p.98.
- 78 *Ibid.*
- 79 E.g., M. I. 171.
- 80 "This Norm [Dhamma] then, wherein I am supremely enlightened -- what if I were to live under It, paying honour and respect?" S. I. 139; A. II. 20.
- 81 *Sn.*228.
- 82 M. I. 190-191.
- 83 S. II. 24; D. III. 279.
- 84 M. I. 163.
- 85 D. I. 1-46.
- 86 Whenever the term "theory" is used in this paper, it should be taken to conote the casting of the experience (Dhamma) in adequate linguistic terms.
- 87 It is known that the final conclusion that the Buddha arrived is the Middle Path. The falsified theories were the two extreme paths, which are, addiction to self-mortification and indulgence in sensual pleasures. S. V. 420; *The Book of the Discipline*, Vol. IV, p.15.
- 88 *The Book of the Disciplines*, Vol. IV (*Mahāvagga*). p.17; S. V. 423.
- 89 *The Book of the Disciplines*, Vol. IV (*Mahāvagga*). p.17; S. V. 423.
- 90 "*usitaṃ brahmacariyaṃ, kataṃ karaṇīyaṃ nāparaṃ itthattāyāti*" M. I. 249.
- 91 Hoffman, *Rationality and Mind in Early Buddhism*, pp.97-98.
- 92 Karl Barth, *Church Dogmatics*, Vol. II, p.279.
- 93 E.g., A. III. 450-451; M. I. 491.
- 94 M. II. 164ff.
- 95 M. I. 318ff.
- 96 D. II. 217; D. III. 5; D. III. 227; S. I. 9; S. IV. 41; S. IV. 272; V. 343; A. I. 156; A. II. 198.
- 97 *Dhammapada* 160 and 165 also emphasize the importance of one's own direct experience.
- 98 A. I. 15.

- 99 M. I. 479-481; M. III. 1-7. According to George Bond, a gradual path to Enlightenment is the later Theravāda commentators' invention as the "hermeneutic strategy" to make "immeasurable," "profound," and "extraordinary" teachings of the Buddha understandable to "ordinary human beings, with only mundane reason and knowledge." See *The Word of the Buddha*, p.32 and "The Gradual Path as a Hermeneutical Approach to the Dhamma," in *Buddhist Hermeneutics*, ed. by Donald S. Lopez, Jr, p.33. However, a gradual path is clearly the Nikāya's. Many suttas of the Nikāya texts are written based upon "anupubbi-kathā" (a gradual instruction), "anupubba-sikkhā" (a gradual training), "anupubba-kiriya" (a gradual doing) and "anupubba-paṭipadā" (a gradual course).
- 100 It should be noted, however, that in the historical process, both the Buddha and Dhamma gradually became objects of religious belief. The Buddha, the interpreter of Dhamma in Early Buddhism, seems to be transformed into the truth giver in the later Mahāyāna Buddhism and Dhamma, a theory of conventional and phenomenal reality in Early Buddhism, is transformed into absolute reality or truth itself in the later Mahāyāna Buddhism.
- 101 *Key Ideas in Human Thought*, ed., Kenneth Mcleish, 1993 ed., s.v., "science."
- 102 *Ibid.*; *The Hutchinson Dictionary of Ideas*, 1994 ed., s.v., "science."
- 103 "Yo paṭiccasamuppādaṃ passati so dhammaṃ passati." M. I. 190-191.
- 104 S. II. 26.
- 105 Kalupahana, *A History of Buddhist Philosophy*, p.55.
- 106 S. II. 59.
- 107 Alfred Jules Ayer, *Language, Truth and Logic*, pp.97-98.
- 108 David J. Kalupahana, *A History of Buddhist Philosophy*, pp.53-54.
- 109 M. III. 63; S. II. 69.
- 110 For the Buddha, however, such knowledge itself as knowledge was not his primary concern. He consistently stated that deeply knowing many things (*abhiññāya anakkhāta*), he did not speak. Cf. S. V. 438. His knowledge was utilized only for a very specific purpose: Suffering (*dukkha*), its arising, its ceasing, and the practice that leads to the ceasing.
- 111 For a basic causal ethical principle, see Taniguchi, "Methodology of Buddhist Biomedical Ethics," pp.35-36.
- 112 A. I. 28.
- 113 A. I. 250.
- 114 S. II. 25-26. See Kalupahana's *Causality: The Central Philosophy of Buddhism*, pp.91-93.
- 115 D. II. 55; S. II. 92.
- 116 *Ibid.*
- 117 Ayer, *Language, Truth and Logic*, pp.59-87.
- 118 Hoffman, *Rationality and Mind in Early Buddhism*, p.98-99.
- 119 See Taniguchi, "Methodology of Buddhist Biomedical Ethics," pp.44-45.
- 120 "... knowledge is a private thing for Early Buddhism. Even belief in the Four Noble Truths does not count as knowledge unless one has investigated them personally, verified them for oneself. For Early Buddhism, "public knowledge" would be a contradiction in terms." Henry Cruise, "Early Buddhism: Some recent misconceptions," *Philosophy East and West* 33, No.2 (April 1983): 150. I think Cruise here uses the term "knowledge" in the sense of "experience" and "verification," instead of "information." I disagree with Hoffman's criticism against Cruise's argument on this issue. See Hoffman, "Buddhist Belief 'In'," 383ff.
- 121 A. II. 187-188.
- 122 *Key Ideas in Human Thought*, Kenneth Mcleish, ed., p.661.
- 123 Thomas S. Kuhn, *The Structure of Scientific Revolutions*, p.10, pp.19-20.
- 124 See Cruise, "Early Buddhism: Some recent misconceptions," 151.
- 125 *Key Ideas in Human Thought*, p.661.
- 126 A radical progression of science may enable us to measure the intensity and degree of the mental activities by quantitation: A's intensity of activated anger (*dosa*) when he was insulted

- by his friend is 64 degree or B's self-centeredness (*taṅhā*) when she had a fight with her husband is 64%. Suppose A focuses on the practice of mindfulness/insight (*sati*), then, we may even be able to measure the reduction of A's degree of anger (*dosa*). Further development of science may even enable to come to a statistics of relationship between the degree of A's original anger (*dosa*) or of B's self-centeredness (*taṅhā*) and the degree of suffering (*dukkha*) of A or B. Then, one may call it "science of ethics." But, the problem is its extreme difficulty of measuring the activity of human mind by numbers and statistics, for first of all one has to objectively define "anger," "hatred" or "suffering" by clearly making a border-line between them.
- 127 E.g., Sopāka, a seven year old boy, *Theragāthā* 480-486; Sunīta, a child road-sweeper, *Theragāthā* 620-631; Rahula, the Buddha's son, *M.* II. 414-420.
- 128 Geoffrey P. Redmond, "Science and Buddhism: A Critical Review," Presentation at the Taiwan Conference, (August, 1994), p.5.
- 129 *M.* I. 482; *M.* II. 31; *M.* II. 126; *A.* I. 220. I do not discuss the doctrinal issue of the Buddhist notion of omniscience, here.
- 130 *D.* III. 76; *S.* I. 62; *S.* V. 197; *S.* V. 343; *A.* II. 48.
- 131 *S.* IV. 52. Another sutta defines "the all" (*sabba*) by the first 12 objects of the 18 objects.
- See *S.* IV. 14. The Buddha included all phenomena in the above 12 or 18 objects. The Buddha is called as the "all-knower" (*sabbāñṇu*) and the "knower of the universe" (*lokavidu*). See *D.* III. 76; *S.* I. 62; *S.* V. 197; *S.* V. 343; *A.* II. 48.
- 132 *M.* I. 112.
- 133 N. Ross Reat uses the term "atheist" to label himself a "Buddhist." Cf. "Pluralism, Deconstructionism, and World Theology," Presentation at AAR Congress at Chicago, 1994. Alfred Bloom once suggested me to use the term "non-theistic" instead of "atheistic" to depict the nature of Buddhism to avoid a potentially negative connotation of the term in the West, such as "amoral" or "areligious."
- 134 *Encyclopedia of Religion*, 1987 ed., s.v. "Hermeneutics," by V. Harvey.
- 135 *Ibid.*
- 136 "*abhiññāya anakkhātam*" *S.* V. 438.
- 137 *S.* V. 437.
- 138 Michio Kaku, "The Harmony Between Modern Science and Religion: The New Unification in Physics," key-note speech at the Buddhist Churches of America Ministers Association and National Council Meeting Banquet in Palo Alto, California, February 25, 1995.
- 139 *Sn.* 560.
- 140 *D.* I. 49; *Sn* 352.
- 141 *M.* I. 161-163.



## 平成10年度鹿児島大学歯学部公開講座 「多様なニーズに応える歯科医療」

場所：県歯科医師会館

第1回 7月26日(日) 午後

歯科医療と倫理的ディレンマ

谷口 昌子 助教授 (倫理学)

口腔領域の疼痛と違和感

杉原 一正 教授 (口腔外科学)

第2回 8月23日(日)

患者の心理

梶原 和美 講師 (心理学)

歯周病の予防と治療

中島 秀喜 教授 (口腔細菌学)

第3回 9月20日(日)

高齢歯科患者の全身的問題点

梶山 加綱 教授 (歯科麻酔学)

姿勢と咬合

伊藤 学而 教授 (歯科矯正学)

### 実施報告

世話人 伊藤 学而

本講座は、鹿児島大学創立五十周年記念協賛事業として企画し、鹿児島県歯科医師会との共催で開催された。当初から歯科医師を対象としたリフレッシュ教育の方向で検討を進め、具体的なテーマについては歯科医師会学術委員会と協議を重ねて煮詰めるという手順をとった。対象は鹿児島県歯科医師会会員20名であった。

実施の形態として少人数の討論形式をとり、しかも各テーマに3時間を充てたので、自由な雰囲気ですべて十分に討論することができた。また、各テーマは歯科医師の要望に基づいて設定した今日的なテーマであったので、受講者、歯科医師会役員、講師陣のいずれからも好評を得た。このことは、今後の公開講座の企画立案に参考になるとと思われる。

鹿児島大学創立五十周年記念協賛事業  
**平成10年度鹿児島大学歯学部公開講座**  
**「寝たきり老人の歯科診療について」**

於：日置郡伊集院町「十八番館」平成10年10月3日

開会式

- |                      |                         |
|----------------------|-------------------------|
| 1. 寝たきり老人の全身の偶発症と問題点 | 梶山 加綱 (歯学部附属病院歯科麻酔科教授)  |
| 2. 寝たきり老人の心理臨床       | 梶原 和美 (歯学部歯科基礎科学講座・講師)  |
| 3. 寝たきり老人の口腔疾患とその対処法 | 園田 悟 (歯学部附属病院第二口腔外科・講師) |
| 4. 寝たきり老人の齲蝕治療と口腔ケア  | 鳥居 光男 (歯学部歯科保存学講座1・教授)  |
| 5. 寝たきり老人の予防と補綴治療    | 長岡 英一 (歯学部歯科補綴学講座2・教授)  |
| 6. 総合討論              |                         |
| 7. 修了式               |                         |

公開講座を終えて

世話人・北野 元生 (歯学部口腔病理学講座・教授)

平成10年度後半期の歯学部公開講座は申木野・日置市郡歯科医師会との共催で、10月3日午後、日置郡伊集院町において開催された。公開講座のタイトルは「寝たきり老人の歯科診療について」であった。本講座の内容の特異性と今日性はタイトル名からも理解されると思うが、聴講対象を歯科医師に限定せず、歯科衛生士、歯科技工士などの歯科医療従事者をはじめ、医療や保健・福祉の現場に携わる人々や行政関係の人々の参加を呼びかけたところ、予測をはるかにオーバーして70名近い出席者があった(定員は約35名)。主催者としては、まことに喜びに耐えなかった。

本講座は、共催者の申木野日置郡歯科医師会と極めて念入りな意見交換と調整の末にテーマが「寝たきり老人の歯科診療について」と決定した。テーマに沿って上記のようにかなり多面的な5項目を選び、それぞれ専門的な立場から5人の講師による講義をお願いした。全部の講義の終了後、講師及び聴講生が参加し、総括的な討論が行われた。講座の内容が極めて時宜を得ていることもあり、討論は極めて活発であり且つ生産的であった。

講義については、内容的にやや専門的に片寄り過ぎるものなどがあり、またかなり多彩であったにも拘わらず、全体に散漫になることもなく、しかもディスカッションのレベルの高さが、本公開講座全体を感銘深いものに仕上げたと思われる。

現在、高齢者の増加は必然的に寝たきり老人を数多く生み出しており、高齢者の医療や介護を担う医療・福祉従事者の専門的知識と技術に対する関心は今後も益々高くなるであろう。医療や福祉あるいは介護の現場に、本講座の主旨が生かされることを希望している。

本公開講座の開講に際して、申木野日置郡歯科医師会の絶大なご支援をいただいた。とくに会長の門松秀久先生をはじめ、役員の方には一方ならぬご尽力をいただいた。なお、本公開講座の世話人として、申木野日置市郡歯科医師会・石窪浩三副会長と鹿児島大学歯学部教授・北野元生が当たった。事務は鹿児島大学歯学部総務課学生係・山口尚美事務官が担当した。

鹿児島大学歯学部発表論文（1997年SCIリスト雑誌分）

1. Fujimiya, K., Sugihara, K. & Nishikawa, T.: Experimental study on the role of osteoclasts and free radicals in the mandibular invasion of VX2 carcinoma in Japanese white rabbits. *Bone*, 20, 245-250, 1997
2. Gao, Y., Fukuda, A., Katsuraya, K., Kaneko, Y., Mimura, T., Nakashima, H. & Uryu, T.: Synthesis of regioselective substituted curdlan sulfates with medium molecular weights and their specific anti-HIV-1 activities. *Macromolecules*, 30, 3224-3228, 1997
3. Iki, K., Kawahara, K., Sawamura, S., Arakaki, R., Sakuta, T., Sugiyama, A., Tamura, H., Sueda, T., Hamada, S. & Takada, H.: A novel component different from endotoxin extracted from *Prevotella intermedia* ATCC 25611 activates lymphoid cells from C3H/HeJ mice and gingival fibroblasts from humans. *Infect. Immun.* 65, 4531~4538, 1997
4. Irifune, M., Fukuda, T., Nomoto, M., Sato, T., Kamata, Y., Nishikawa, T., Mietani, W., Yokoyama, K., Sugiyama, K. & Kawahara, M.: Effects of ketamine on dopamine metabolism during anesthesia in discrete brain regions in mice: comparison with the effects during the recovery and subanesthetic phases. *Brain Res.*, 763, 281-284, 1997
5. Irifune, M., Sato, T., Masuyama, T., Nomoto, M., Fukuda, T., Kawahara, M. & Nishikawa, T.: Hyperlocomotion during recovery from isoflurane anesthesia is associated with increased dopamine turnover in the nucleus accumbens and striatum in mice. *Anesthesiology*, 86, 464-475, 1997
6. Kawahata, N., Ono, H., Kamashita, Y., Hamano, T. & Nagaoka, E.: Application of a three-dimensional reconstruction method to analysis of the residual ridge. *J. Oral Rehab.*, 24, 936-941, 1997
7. Kawahata, N., Ono, H., Nishi, Y., Hamano, T. & Nagaoka, E.: Trial of duplication procedure for complete dentures by CAD/CAM. *J. Oral Rehab.*, 24, 540-548, 1997
8. Kitada, K., Inoue, M. & Kitano, M.: Experimental endocarditis induction and platelet aggregation by *Streptococcus anginosus*, *Streptococcus constellatus* and *Streptococcus intermedius*. *FEMS Immun. Med. Microbiol.*, 19, 25-32, 1997
9. Kubo, K., Tsukasa, N., Uehara, M., Izumi, Y., Ogino, M., Kitano, M. & Sueda, T.: Calcium and silicon from bioactive glass concerned with formation of nodules in periodontal-ligament fibroblasts in vitro. *J. Oral Rehab.*, 24, 70-75, 1997
10. Kuramitsu, H., Tokuda, M., Yoneda, M., Duncan, M. & Cho, M. -I.: Multiple colonization defects in a cysteine protease mutant of *Porphyromonas gingivalis*. *J. Period. Res.*, 32, 140~142, 1997
11. Kuwashima, Y., Kurosumi, M., Kobayashi, Y., Tanuma, J. & Kishi, K.: Inverse correlation between bcl-2 expression and cell growth fraction in human endometrial adenocarcinoma tissue. *Anticancer Res.*, 17, 3773-3776, 1997
12. Li, T. J., Hirayama, Y. & Kitano, M.: Glutathione S-transferase  $\pi$ -class as a

- tumour marker in lingual preneoplastic and neoplastic lesions of rats and humans. *Virchows Arch.*, 431, 37-43, 1997
13. Li, T. J., Kitano, M., Mukai, H. & Yamashita, S.: Oral sebaceous carcinoma: report of a case. *J. Oral Maxill. Surg.*, 55, 751-754, 1997
  14. Li, T. J., Kitano, M., Tsuneyoshi, M., Sonoda, S. & Mimura, T.: Intra-articular fibroma of tendon sheath in the temporomandibular joint. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. & Endod.*, 84, 407-410, 1997
  15. Li, T. J., Kitano, M., Yoshida, A., Iwashige, Y. & Yamashita, S.: Myxoglobulosis in an extravasation mucocele of the lower lip., *J. Oral Pathol. Med.*, 26, 342-344, 1997
  16. Matsumura, H., Tanaka, T., & Atsuta, M.: Bond of silver-palladium-copper-gold alloy with thiol derivative primers and tri-n-butylborane initiated luting agents. *J. Oral Rehabil.*, 24, 291-296, 1997
  17. Matsumura, H., Tanaka, T. & Atsuta, M.: Effect of aciditic primers on bonding between stainless steel and auto-polymerizing methacrylic resins. *J. Dent.*, 25, 285-290, 1997
  18. Matsushita, K., Uchiyama, T., Igarashi, H., Ohkuni, H., Nagaoka, S., Kotani, S. & Takada, H.: Possible pathogenic effect of *Streptococcus mitis* superantigen on oral epithelial cells. *Advances in Experimental Med. & Biol.*, 418, 685-688, 1997
  19. Matsuyama, T., Izumi, Y. & Sueda, T.: Culture and characterization of human junctional epithelial cells. *J. Periodontol.*, 68, 229-239, 1997
  20. Morinushi, T., Lopatin, D. E. & Poperin, N. V.: The Relationship between gingivitis and the serum antibodies to the microbiota associated with periodontal disease in children with downs syndrome: *J. Periodontol.*, 68, 626-631, 1997
  21. Nakano, M., Itoh, Y., Mizuno, T. & Nakashima, H.: Polysaccharide from *Aspalathus linearis* with strong anti-HIV activity. *Biosci. Biotech. Biochem.*, 61, 267-271, 1997
  22. Nakano, M., Nakashima, H. & Itoh, Y.: Anti-human immunodeficiency virus activity of oligosaccharides from rooibos tea (*Aspalathus linearis*) extracts in vitro. *Leukemia, Suppl.*, 3, 128-130, 1997
  23. Nikoh, N., Iwabe, N., Kuma, K., Ohno, M., Sugiyama, T., Watanabe, Y., Yasui, K., Shi-cui, Z., Hori, K., Shimura, Y. & Miyata, T.: An estimate of divergence time of parazoa and eumetazoa and that of cephalochordata and vertebrata by aldolase and triose phosphate isomerase clocks. *J. Molecular Evolution*, 45, 97-106, 1997
  24. Ohnishi, T., Nakamura, O., Arakaki, N. & Daikuhara, Y.: Effect of phosphorylated rat fetuin on the growth of hepatocytes in primary culture in the presence of human hepatocyte-growth factor. Evidence that phosphorylated fetuin is a natural modulator of hepatocyte-growth factor. *Eur. J. Biochem.*, 243, 753-761, 1997
  25. Premanathan, M., Kathiresan, M., Nakashima, H. & Yamamoto, N.: In vitro anti-human immunodeficiency virus activity of some indian medicinal plants. *Tropical Biomed.* 14, 65-69, 1997

26. Premanathan, M., Nakashima, H., Igarashi, R., Mizushima, Y. & Yamada, K.: Lecithinized superoxide dismutase : an inhibitor of human immunodeficiency virus replication. *AIDS Res. Human Retroviruses*, 13, 283-290, 1997
27. Sato, I., Sato, T. & Shimada, K.: Communication between the superior cervical sympathetic ganglion and the inferior laryngeal nerve. *J. Anat.*, 190, 147-148, 1997
28. Sato, T., Kamata, Y., Irifune, M. & Nishikawa, T.: Inhibitory effect of several nitric oxide-generating compounds on purified Na<sup>+</sup>, K<sup>+</sup> -ATPase activity from porcine cerebral cortex. *J. Neurochem.*, 68, 1312-1318, 1997
29. Semba, I., Kitano, M., Mimura, T., Sonoda, S. & Miyawaki, A.: Glandular odontogenic cyst; Analysis on cytokeratin and clinicopathological features. *J. Oral Pathol. Med.*, 23, 377-382, 1997
30. Shimada, K. & Sato, I.: Morphological and histological analysis of the thoracic duct at the jugulo-subclavian junction in Japanese cadaver. *Clinical Anat.*, 10, 163-172, 1997
31. Shisa, H., Lu, L., Katoh, H., Kawarai, A., Tanuma, J., Matsushima, Y. & Hiai, H.: The LEXF: a new set of rat recombinant inbred strains between LE/stm and F344. *Mammalian Genome.*, 8, 324-327, 1997
32. Soung-Choi, Y., Won-Kang, B., Lu, R., Osawa, M., Hattori, K., Yoshida, T., Mimura, T., Kaneko, Y., Nakashima, H., Yamamoto, N. & Uryu, T.: Synthesis of sulfated deoxy-ribofuranans having selective anti-AIDS virus activity by ring-opening copolymerization of 1,4-anhydro ribose derivatives., *Polymer J.*, 29, 374-379, 1997
33. Suenaga, S., Sonoda, S., Oku, T., Abeyama, K. & Noikura, T.: MRI of the Temporomandibular Joint disk and posterior disk attachment before and after nonsurgical treatment. *J. Computer Assisted Tomog.*, 21, 892-896, 1997
34. Tabata, M., Sugihara, K., Yamashita, S. & Maruyama, I.: An immunohistochemical study of thrombomodulin in oral squamous cell carcinoma and its association with invasive and metastatic potential. *J. Oral Path. Med.*, 26, 258-264, 1997
35. Tanaka, H., Matsuzaki, K., Nakashima, H., Ogino, T., Matsumoto, A., Ikeda, H., Woodruff, B. & Omura, S.: Chloropectins, new anti-HIV antibiotics inhibiting gp120-CD4 binding from *Streptomyces* sp. I. Taxonomy, fermentation, isolation, and physico-chemical properties and biological activities. *J. Antibiotics*, 50, 58-65, 1997
36. Uryu, T., Katsuraya, K. & Nakashima, H.: Synthesis of sulfated alkyl oligosaccharides with potent anti-HIV-1 activity. *Macromol. Symp.*, 120, 147-158, 1997
37. Yamada, G., Ueno, K., Nakamura, S., Hanamura, Y., Yasui, K., Uemura, M., Eizuru, Y., Mansouri, A., Blum, M. & Sugimura, K.: Nasal and Pharyngeal Abnormalities Caused by the Mouse Goosecoid Gene Mutation. *Biochemical and Biophysical Res. Communication.*, 233, 161-165.1997

38. Yasui, K., Sasaki, H., Arakaki, R. & Uemura, M.: Distribution pattern of HNF-3  $\beta$  proteins in developing embryos of two mammalian species, the house shrew and the mouse. *Develop. Growth & Differen.*, 39, 667-676, 1997

## 編 集 後 記

昨年度は特別の合併号であったため、出版がやや遅くなったのはやむを得ない面もあったと思われました。本年度の原稿が集まった時期は、例年より順調であったので、本年度の発刊は期限内に終了するのではないかと考えていました。しかしながら、好事魔多しとはよく言ったもので、私の考えていた事とは裏腹にそれから後の進行状況が悪く、例年よりもむしろ遅れる心配の方が強くなって来ました。そこで、私も気合いを入れ直して対応しました。

今年も一般公募をしましたが、ここ数年公募を出来るような状況になる事は考えにくく、新任や退官の先生の分を消化するのがやっとなのではないかと考えられます。最後になりましたが、紀要の発刊に種々ご協力いただいた方々に厚くお礼申し上げます。

(編集委員 小椋 正)

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