Applications of Raman luminescence spectroscopy in tumor diagnosis.

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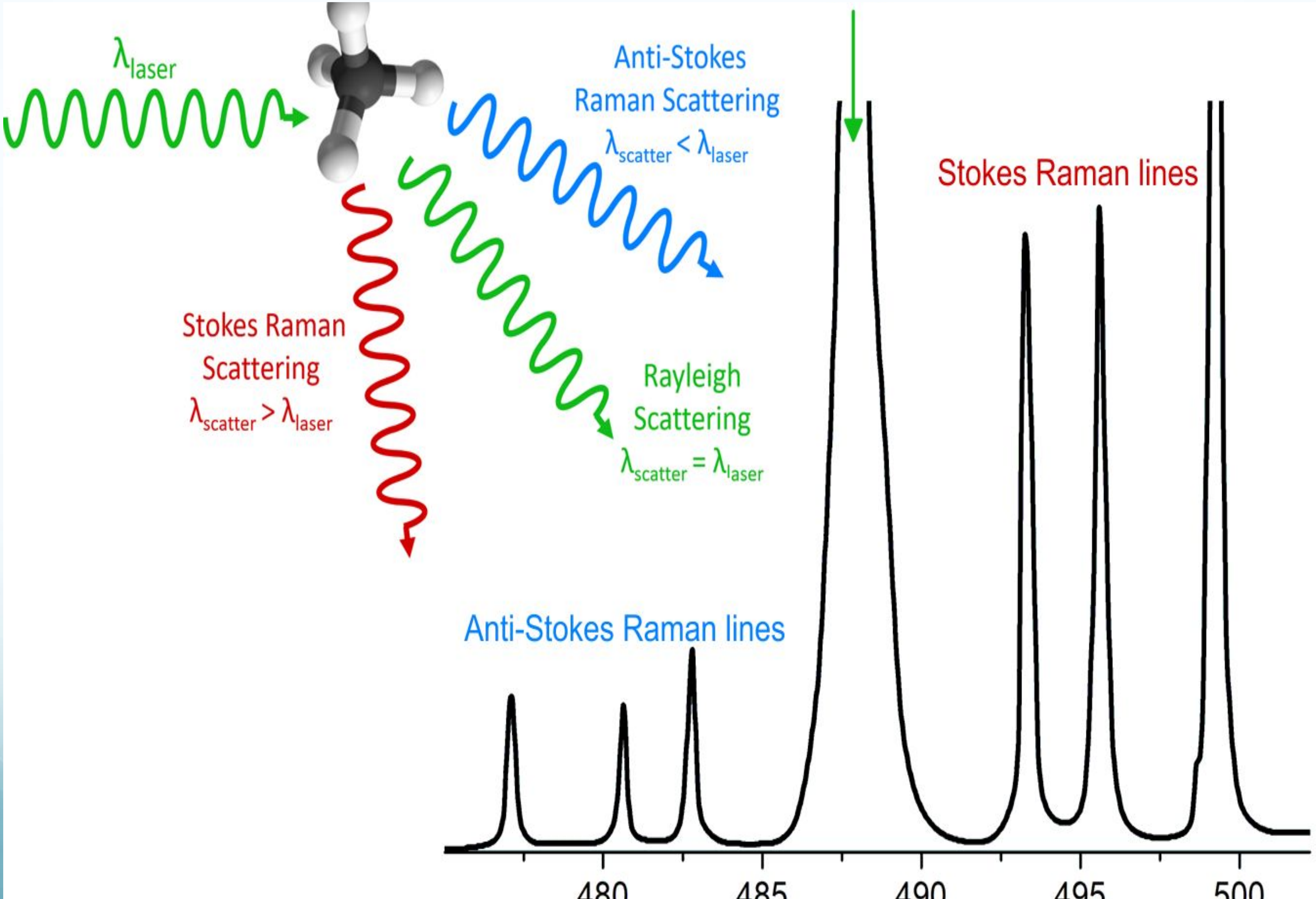
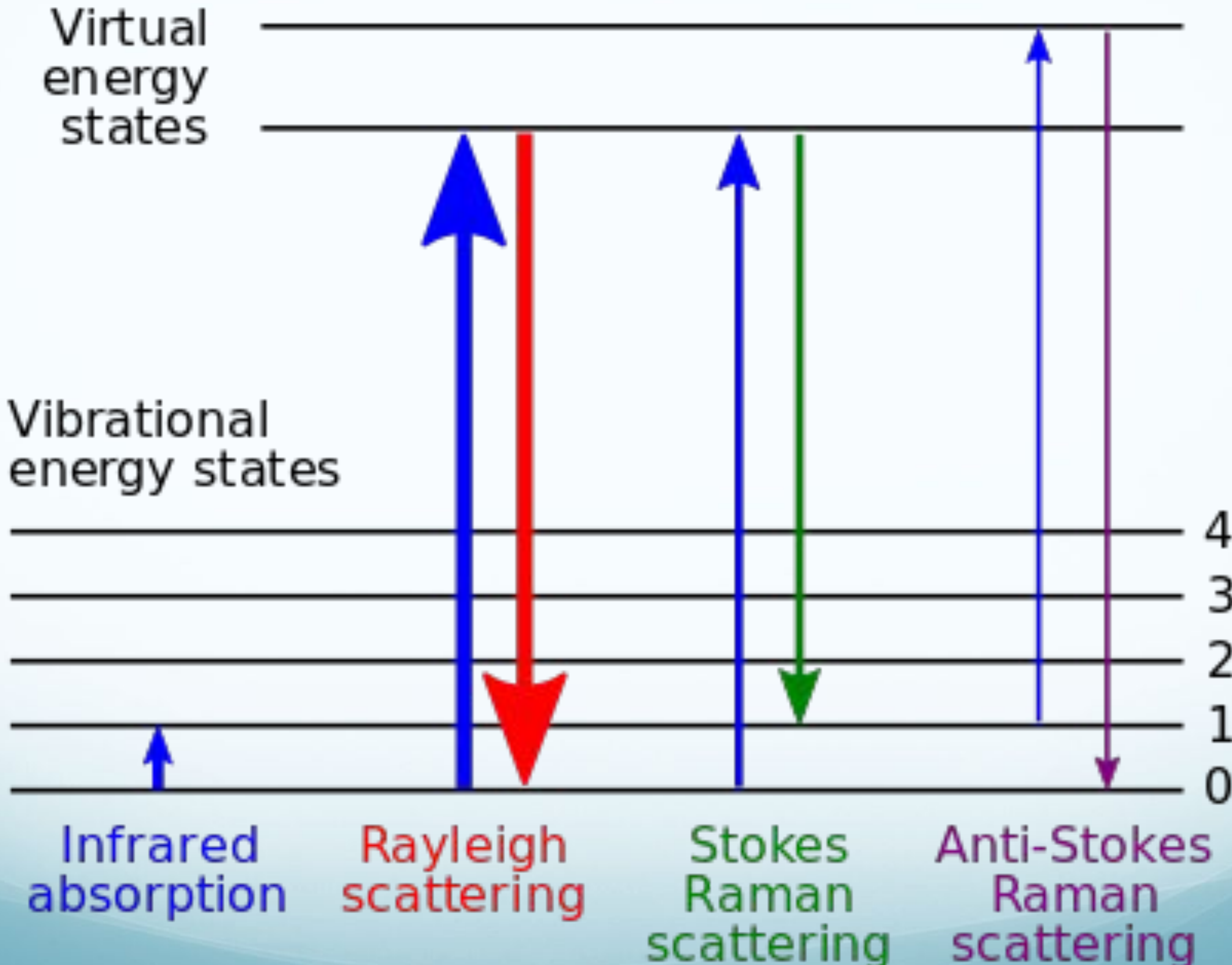
Year 2
General medicine.

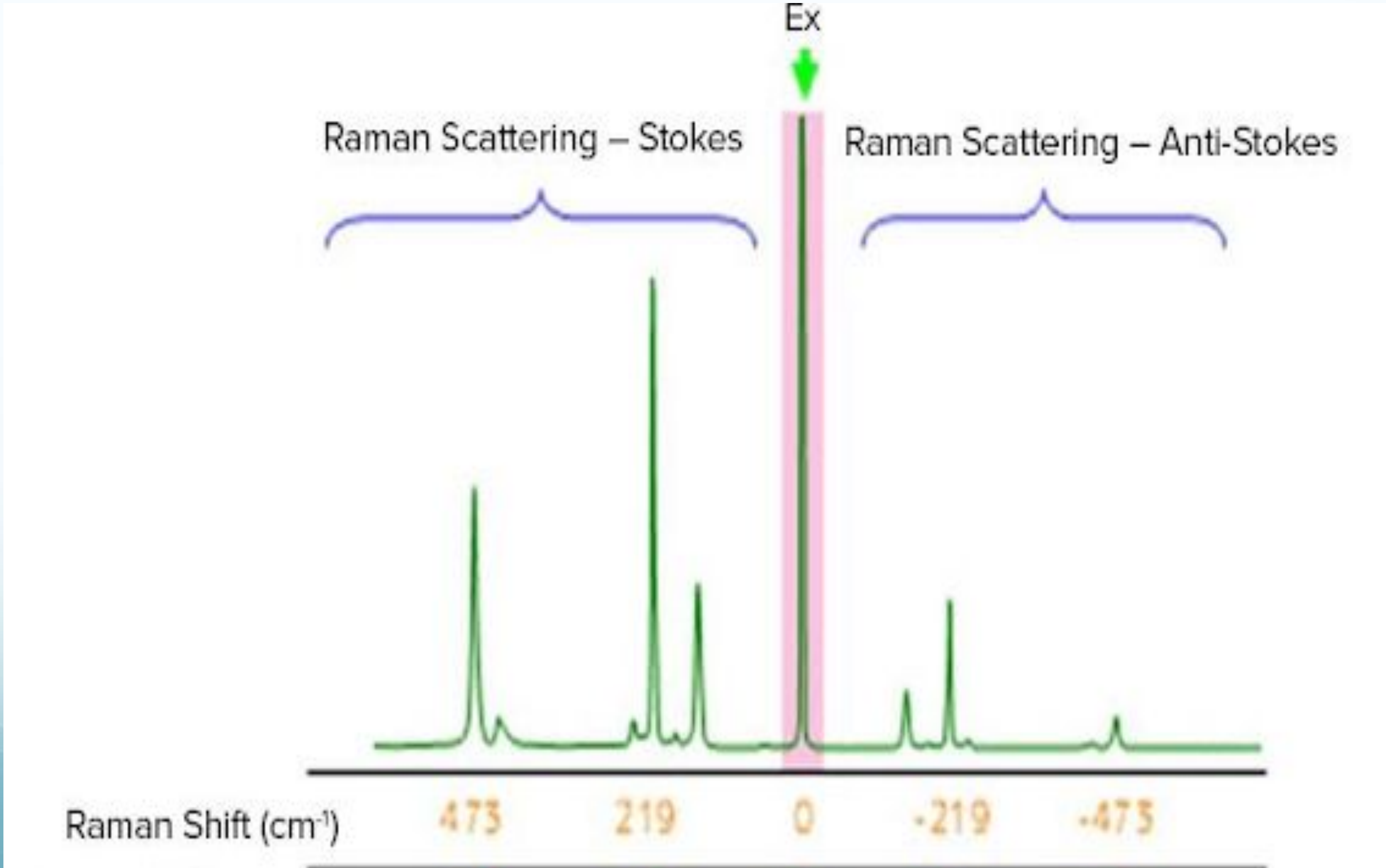
The basic principle

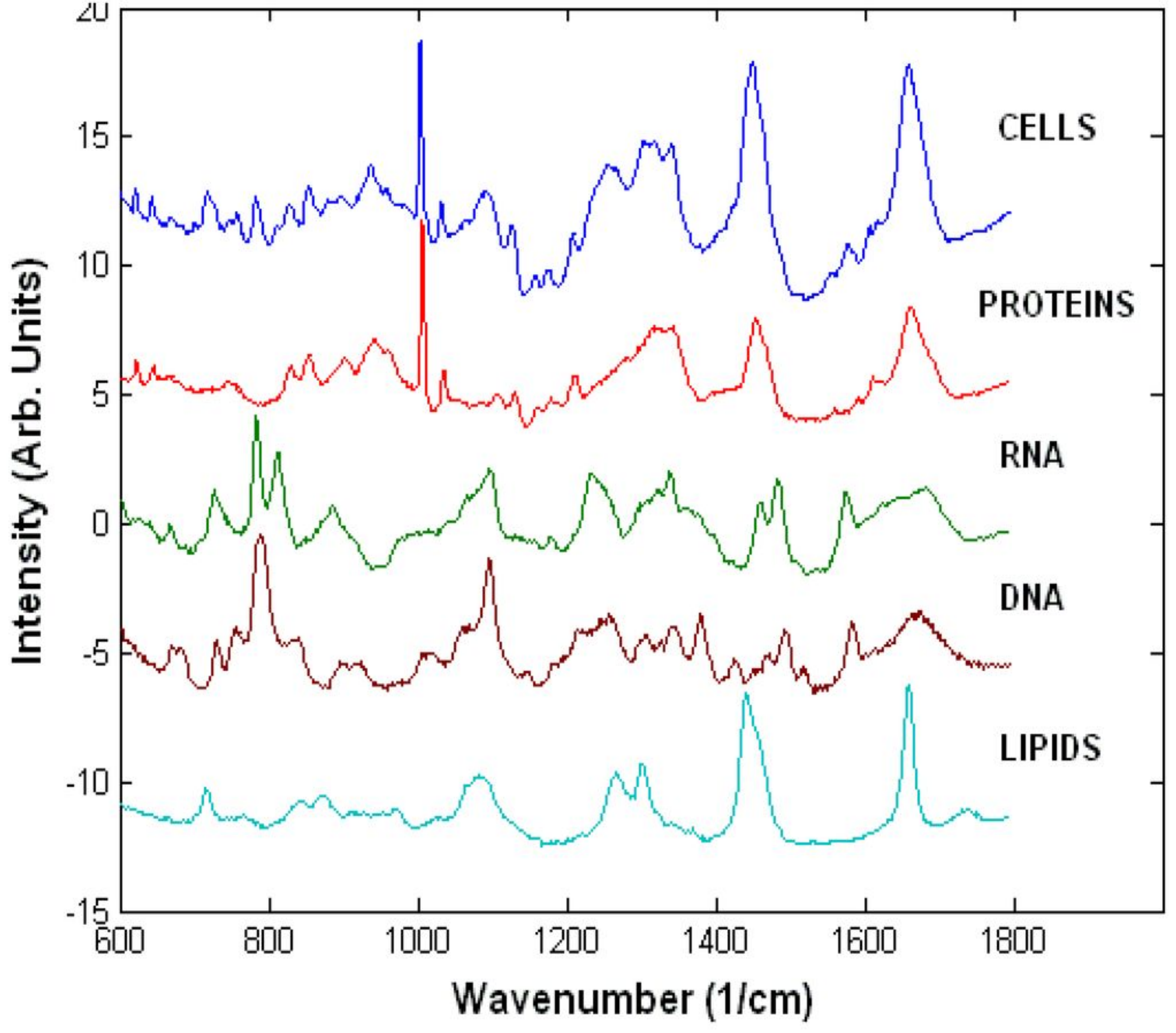



Virtual energy states
Vibrational energy states
4
3
2
1
0
Infrared absorption
Rayleigh scattering
Stokes Raman scattering
Anti-Stokes Raman scattering

Raman shift

The Raman shift is associated with two different energy bands

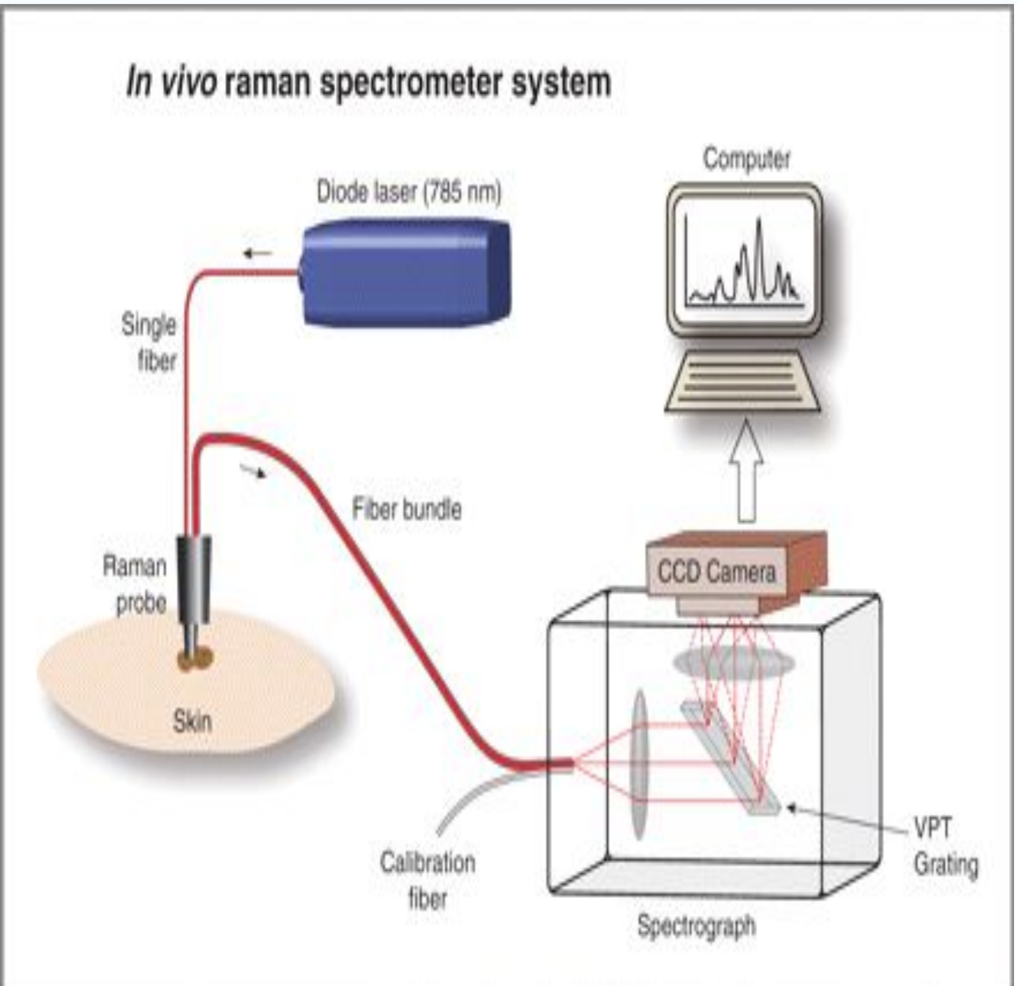


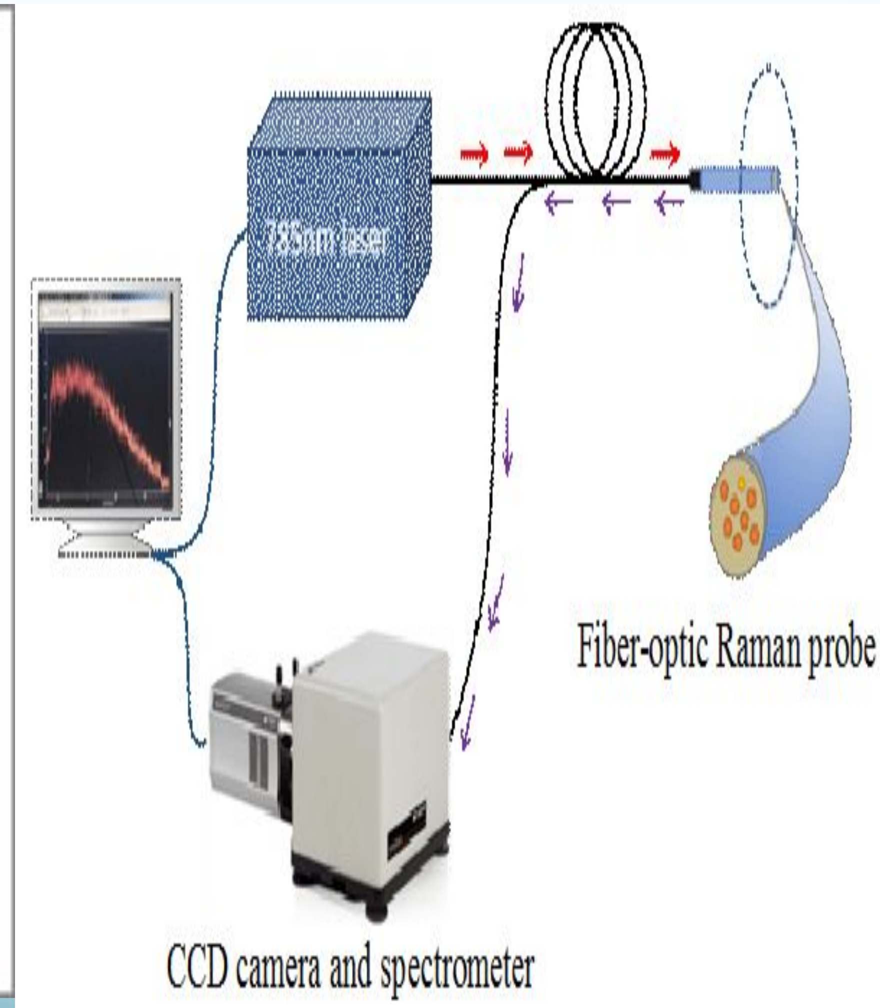


CELLS
PROTEINS
RNA
DNA
LIPIDS
Intensity (Arb. Units)
Wavenumber (1/cm)
20
15
10
5
0
-5
-10
-15
600
800
1000
1200
1400
1600
1800

instrumentation

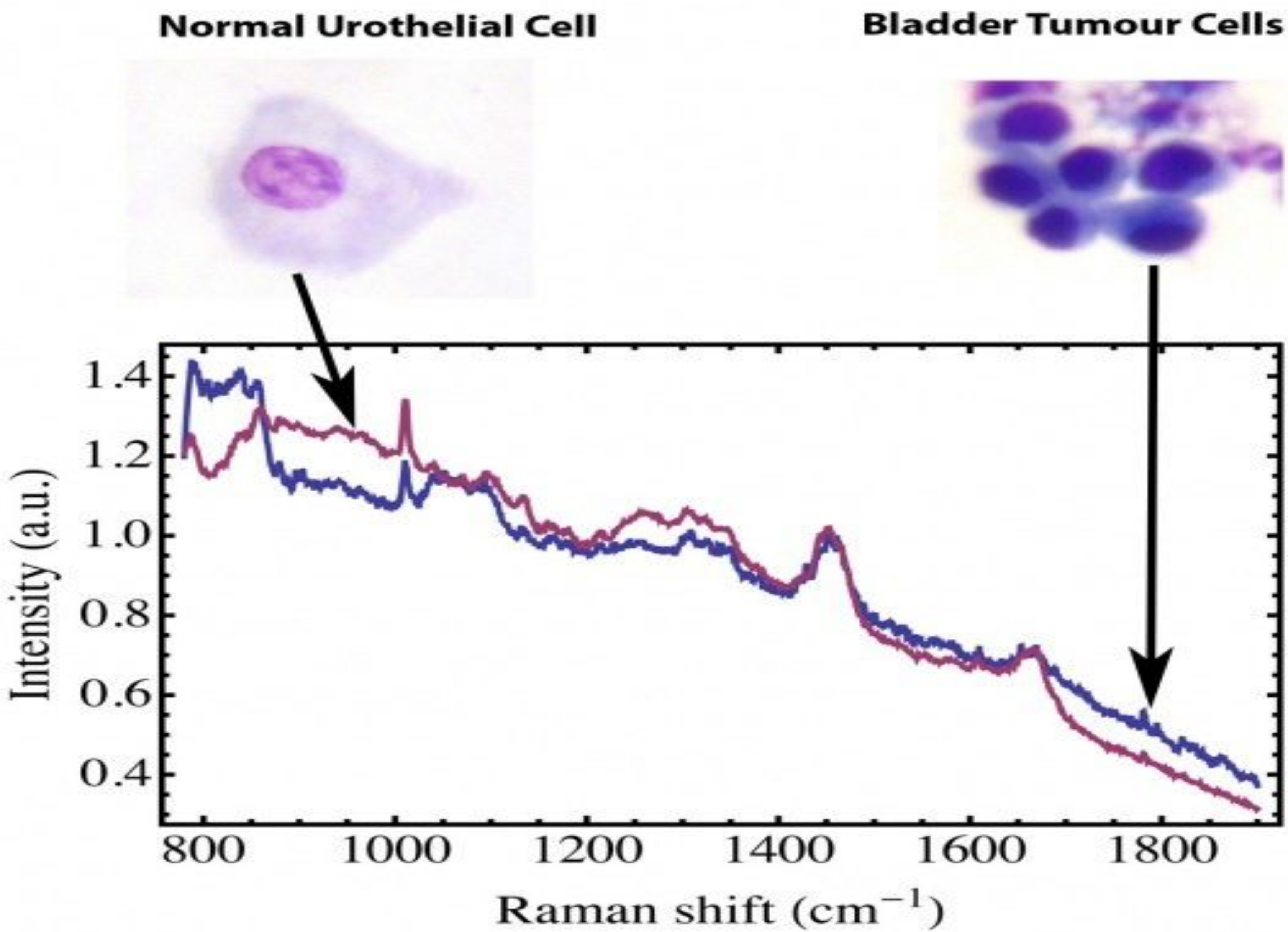
- The typical Raman spectrophotometer setup is shown.

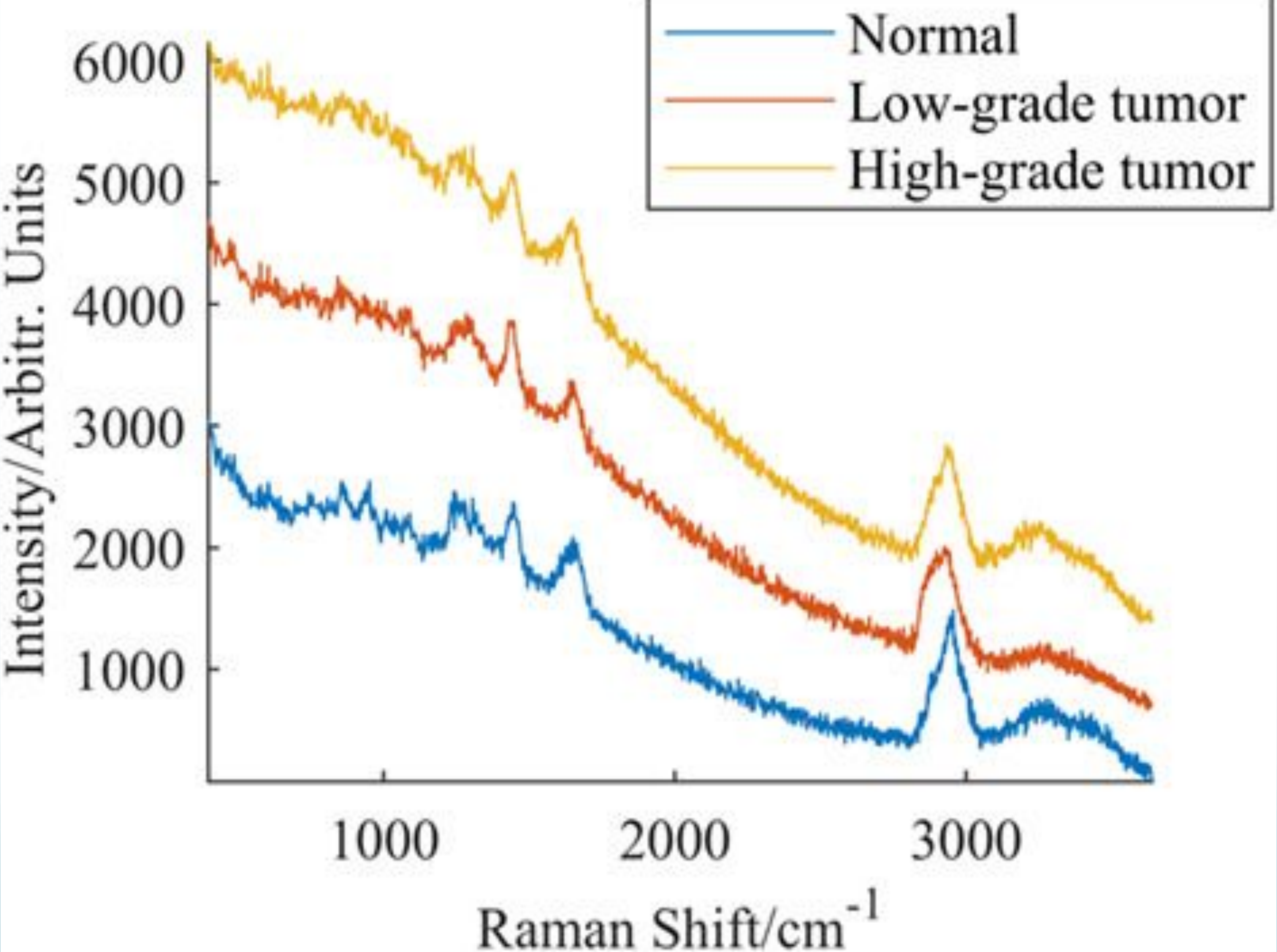




Raman Shift (cm^{-1})	Molecular Assignment [44–46]
756	Tryptophan
782	cytosine and thymine
810	C05–O–P–O–C′3 phosphodiester bands
825	tyrosine (p)
851	ring breathing of tyrosine
876	Tryptophan
936	skeletal mode of polysaccharides
986	C–C or C–O in ribose
1002	ring breathing of phenylalanine
1031	C–H in phenylalanine
1065	C–N, C–C stretch (p)
1081	C–N (p), CC (l)
1095	O–P–O symmetric stretching
1125	C–N str in protein or C–O str in carbohydrates
1155, 1176	Carotenoids
1209	stretching mode in phenylalanine and tyrosine
1254	amide III β sheet
1268	amide III (α helix of protein)
1302	CH_2 deformation of phospholipids
1318, 1339	CH_2 twist and bend (nucleic acids, proteins, lipids)
1447	C–H def. nucleic acids, proteins, lipids
1582	adenine, guanine (nucleic acid)
1606, 1665	aromatic amino acids (p)
1654	amide I (p)
2850	CH_2symstr (l)
2878	CH_2asymstr (l)
2929	CH_3symstr (p,l)
2968	CH_3asymstr (p,l)

The different spectrum lines shows the difference between healthy and tumor cells

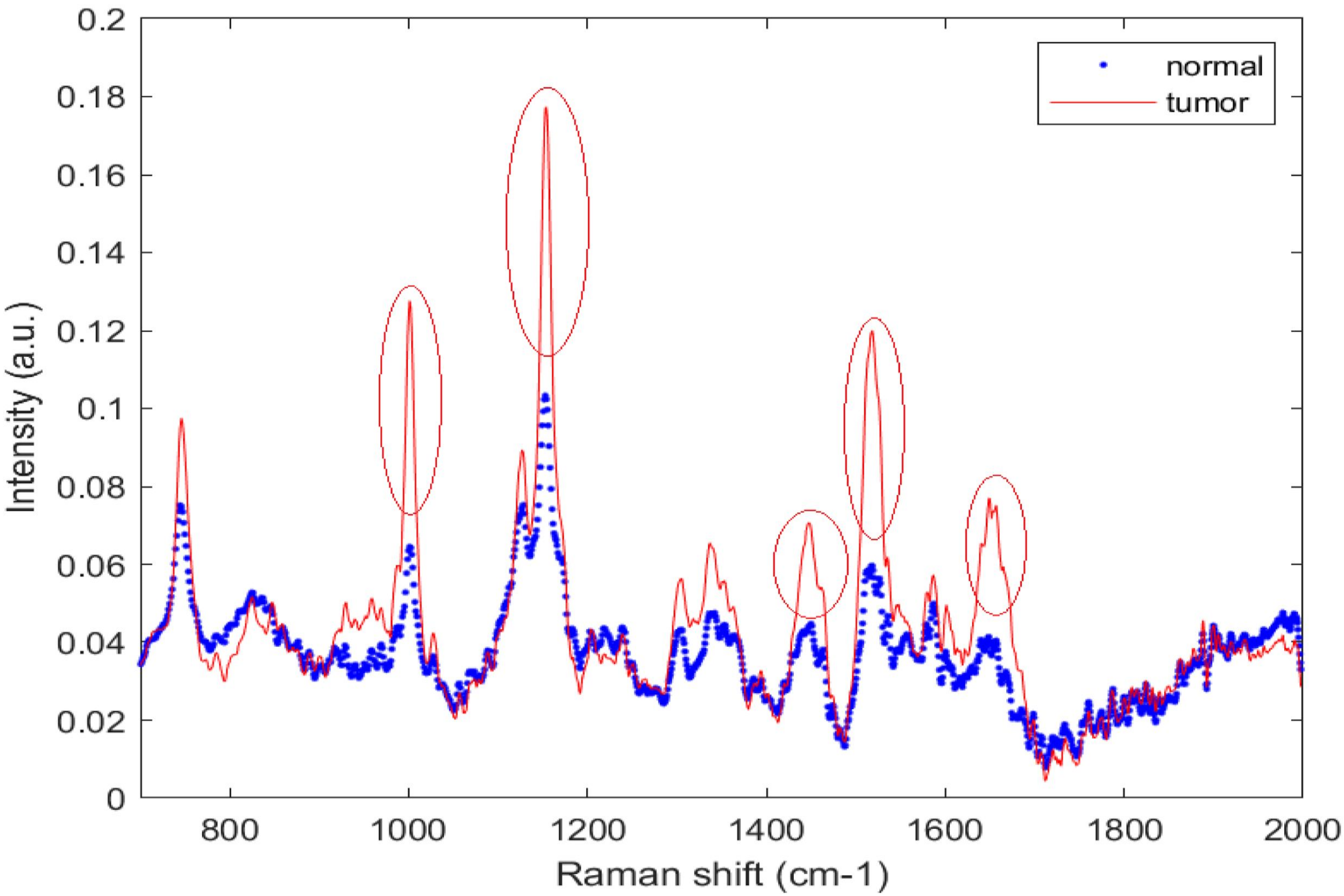




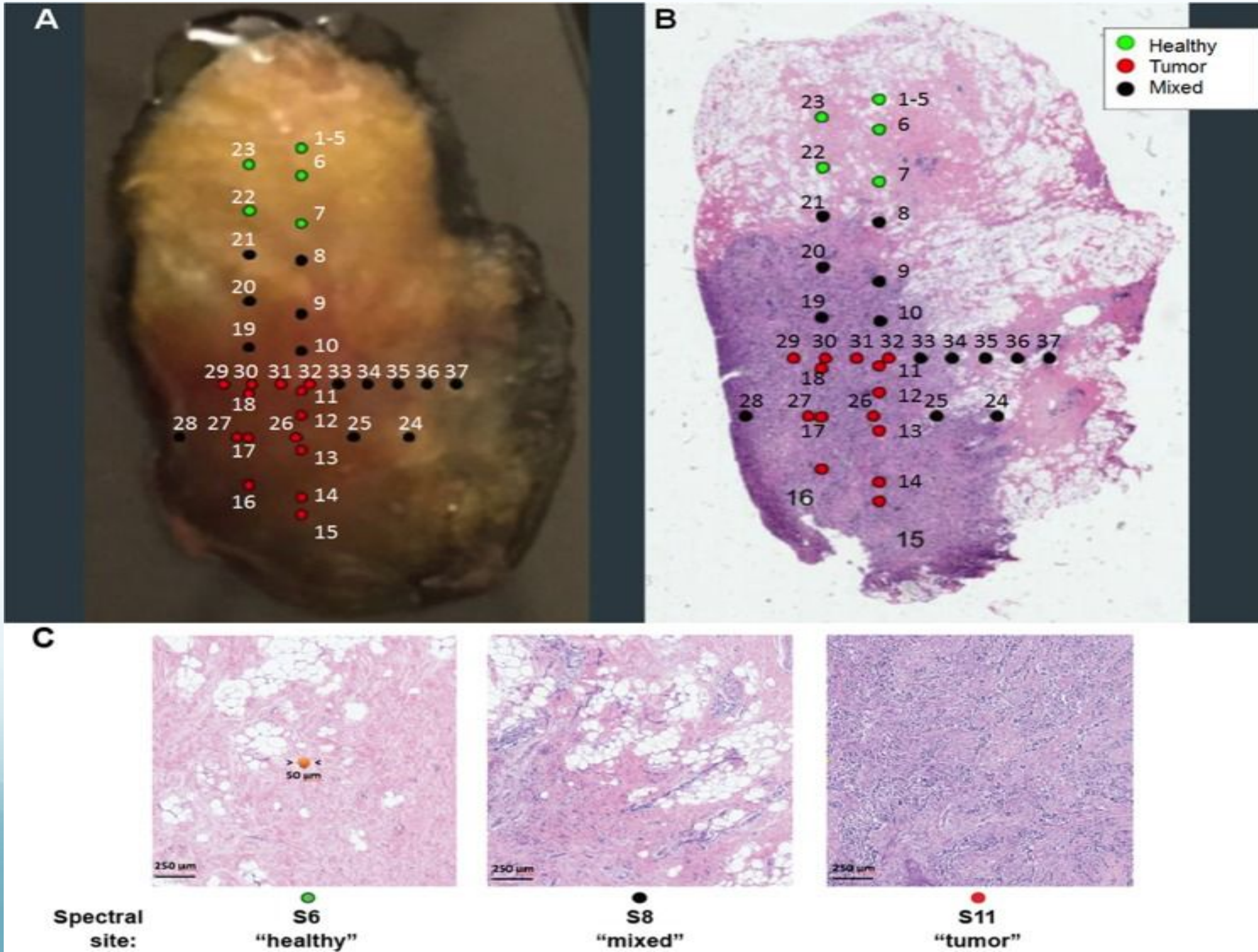
Normal
Low-grade tumor
High-grade tumor
6000
5000
4000
3000
2000
1000
Intensity/Arbitr. Units
1000
2000
3000
Raman Shift/cm^{-1}

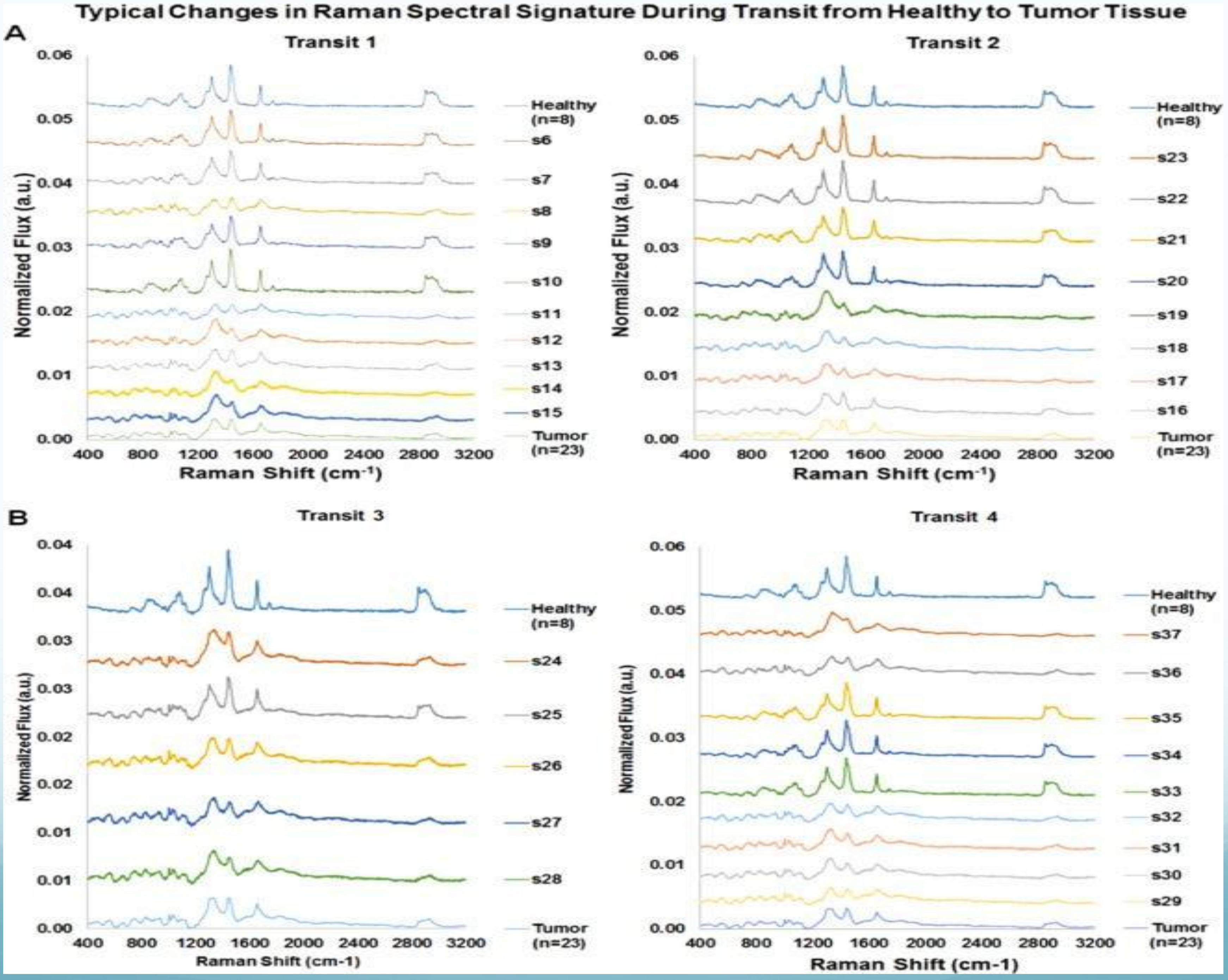
Oral cancer detection

Oral cancer detection



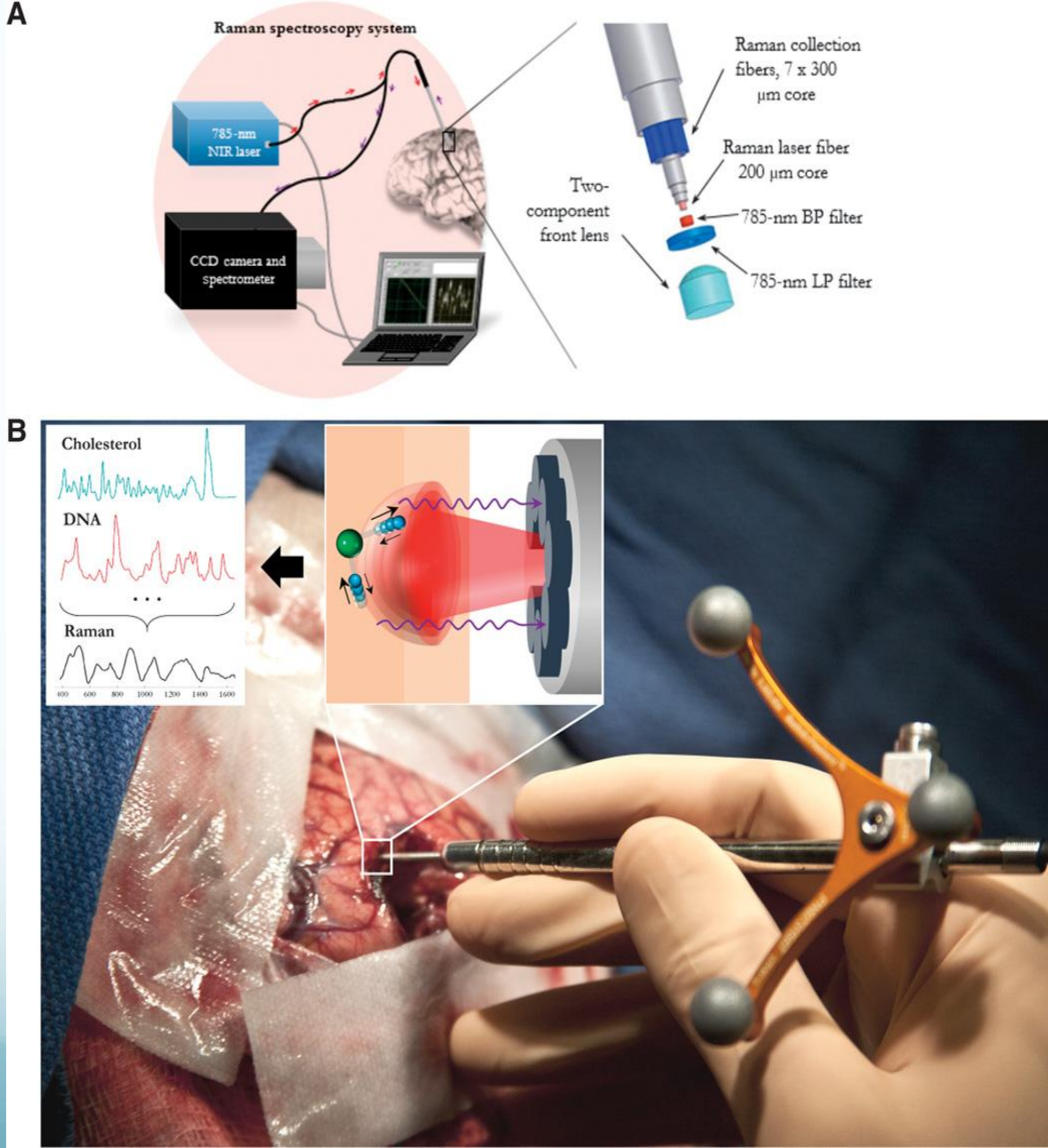
Margin analysis during breast cancer lumpectomy


A
B
C
Healthy
Tumor
Mixed
1-5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29 30 31 32 33 34 35 36 37
50 µm
250 µm
Spectral site:
S6 "healthy"
S8 "mixed"
S11 "tumor"



Typical Changes in Raman Spectral Signature During Transit from Healthy to Tumor Tissue
A
Transit 1
Transit 2
Normalized Flux (a.u.)
Raman Shift (cm-1)
Healthy (n=8)
s6
s7
s8
s9
s10
s11
s12
s13
s14
s15
Tumor (n=23)
s23
s22
s21
s20
s19
s18
s17
s16
B
Transit 3
Transit 4
s24
s25
s26
s27
s28
s37
s36
s35
s34
s33
s32
s31
s30
s29


DANGER
LEICA
ProRaman-L
SYSTEM
LASER
ENWAVE OPTRONICS
Leica


A
Raman spectroscopy system
785-nm NIR laser
CCD camera and spectrometer
Raman collection fibers, 7 x 300 µm core
Raman laser fiber 200 µm core
Two-component front lens
785-nm BP filter
785-nm LP filter
B
Cholesterol
DNA
Raman
400 600 800 1000 1200 1400 1600

In conclusion,

- This technique probes molecular vibrations/rotations associated with chemical bonds in a sample to obtain information on molecular structure, composition, and intermolecular interactions.

- since each sample has a unique composition, the spectroscopic profile arising from Raman-active functional groups of nucleic acids, proteins, lipids, and carbohydrates allows for the evaluation, characterization, and discrimination of tissue type.

- Owing to its high chemical specificity and non invasive detection capability, it is widely employed in cancer screening, diagnosis, and intraoperative surgical guidance.

- The raman techniques could be used on intraoperatively as well as on accessible tissue surface and many different modes of the technique are being developed to increase its scope as diagnostic tool of cancer.

- Therefore, Raman spectroscopy is a promising investigative and diagnostic tool that can assist in uncovering the molecular basis of disease and provide objective, quantifiable molecular information for diagnosis and treatment evaluation.

references

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Thank you for your time.