70. An individual's immune responses can change throughout their lifetime.

Fig. 4.1 shows one person's immune response to the influenza virus when they were first infected and when they were infected two years later by a new, mutated strain of the virus.

The influenza virus has many antigens to which the immune system can respond. Fig. 4.1 shows the response to four of these antigens (A–D).

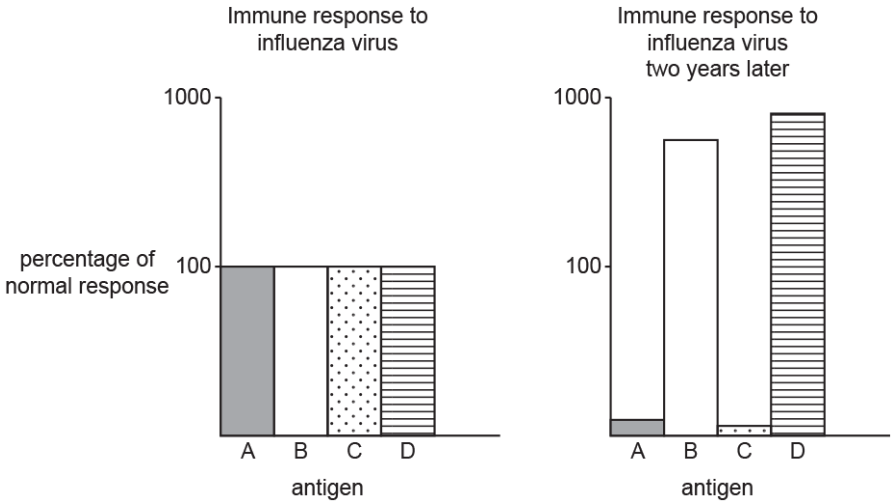


Fig. 4.1

Explain the differences in the person's initial immune response to the influenza virus with their immune response two years later.

_____

_____

_____

_____

_____ **[2]**

71. Fig. 4 shows the concentration of antibodies in a patient's bloodstream following an influenza (flu) vaccination, and then a subsequent infection with the influenza virus.

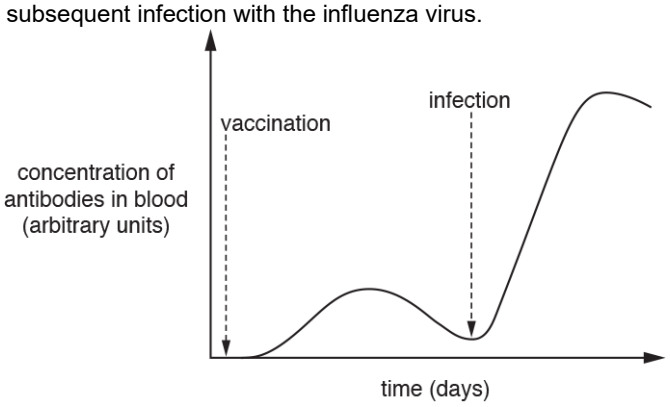


Fig. 4

Describe where the primary and secondary immune responses are taking place on Fig. 4 and explain the differences between the two processes.

_____

_____

_____

_____

_____

_____

_____ **[3]**

72(a). Fig. 25.1 shows the concentration of antibodies in a patient's bloodstream following a vaccination against a common pathogen and subsequent infection with the same pathogen.

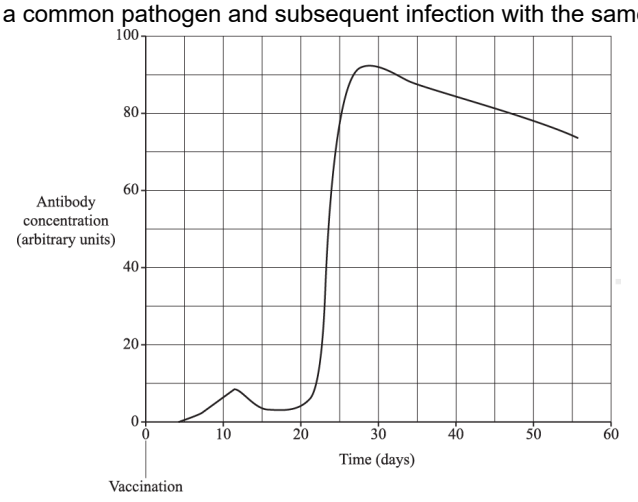


Fig. 25.1

Calculate the rate of antibody production at day 10 in arbitrary units per day.

Answer.....au day^{-1} **[2]**

(b). Explain why the response to the subsequent infection is much bigger than the response to vaccination, as shown in Fig. 25.1.

_____

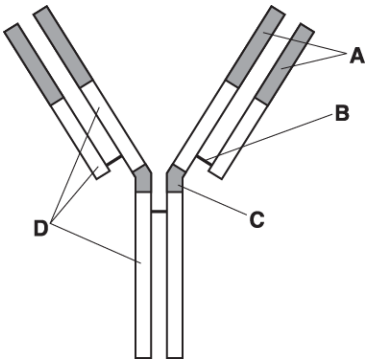
_____

_____

_____

_____ **[3]**

73. The diagram below shows the simplified structure of an antibody.



Which of the letters, **A** to **D** identifies the region of the antibody that allows the distance between the antibody binding sites to vary.

Your answer ☐

[1]

74(a). The concept of molecules with complementary shapes can be used to explain many processes in living things.

Another molecule that relies on a specific shape to bind to a specific compound is an antibody. **Fig. 23.1** shows the generalised structure of an antibody.

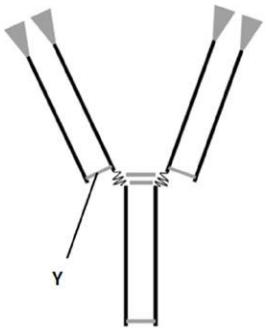


Fig. 23.1

i. Draw a ring on **Fig. 23.1** to show a part of the molecule that has a shape complementary to the shape of an antigen.

[1]

ii. The component labelled **Y** on the antibody is a bond.

State what type of bond is found here and give its function.

---

[2]

(b). Lupus is an autoimmune disease. Lupus occurs when nuclear proteins are exposed and the immune system makes antibodies against these proteins. As a result the proteins clump together. These clumps stick to surfaces such as the blood vessel walls and cause fatigue, joint pain and skin rashes.

i. What is meant by the term *autoimmune disease*?

---

[2]

ii. Suggest why antibodies specific to nuclear proteins are not normally made.

---

[1]

75. Some people are immune to malaria. They produce a specific type of antibody. One way in which antibodies defend the body is by acting as agglutinins.

Outline the action of agglutinins.

---**[2]**

76. Chickenpox is a common disease.

People who have recently recovered from chickenpox can donate plasma so that their antibodies can be given to leukaemia patients with weakened immune systems.

i. Use a tick (✓) to indicate in the table below which type of immunity is functioning in a leukaemia patient when given chickenpox antibodies.

Type of immunity	
natural and active	
natural and passive	
artificial and active	
artificial and passive	

[1]

ii. Explain your answer to part (i).

---**[2]**

77. If a person is bitten by a venomous snake, the immediate treatment is normally to inject the person with the appropriate antibodies.

This is an example of which type of immunity?

A. artificial active immunity
B. artificial passive immunity
C. natural active immunity
D. natural passive immunity

Your answer ☐

[1]

78. Vaccinations are effective in preventing the spread of a range of diseases.

Explain why vaccinations are an example of active immunity.

---

[2]

79. Sjogren's syndrome is an autoimmune condition.

- Family members of Sjogren's syndrome sufferers can often have other autoimmune diseases such as Lupus
- Lupus affects approximately 1 in 1350 of the world's population
- In 2018 the world population was estimated at 7.7×10^9
- The world population is estimated to increase by 1.11% a year
- Around 60% of Lupus sufferers are photosensitive, meaning their symptoms can be triggered by going out in direct sunlight.

i. Using the information provided, calculate how many of the world's Lupus sufferers by the end of 2019 would be photosensitive.

number of photosensitive Lupus sufferers = ... **[2]**

ii. Lupus symptoms include pain in joints, inflammation, fatigue, fever and a skin rash.

Suggest what component of sunlight causes photosensitivity and which symptom is likely to be more common in photosensitive sufferers.

Component of sunlight

_____

Symptom

_____

[1]

iii. Explain what is meant by an autoimmune disease **and** suggest why members of the same family can be sufferers of autoimmune diseases.

_____

_____

_____

_____

_____ **[2]**

80.

Pepsin is a protease enzyme with a polypeptide chain containing 327 amino acids.

Titin is the largest known protein. It has a polypeptide chain containing at least 92 times more amino acids than pepsin.

i. DNA sequences in genes code for polypeptide molecules such as pepsin and titin.

Explain why a process known as transcription is necessary for polypeptide synthesis.

_____

_____

_____

_____ **[2]**

ii. Calculate the minimum length of the DNA base sequence required to code for titin.

Show your working.

Answer ..... **[2]**

iii. * Titin is a fibrous protein. Pepsin is a globular protein.

Compare the properties and functions of fibrous proteins and globular proteins in the human body.

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_____

_____ **[6]**

iv. Another protease enzyme is HIV1 protease, which is essential for the life cycle of the human immunodeficiency virus (HIV). Inhibition of this protease prevents HIV from maturing.

In 1995, saquinavir was the first HIV1 protease inhibitor drug to be approved by the US Food and Drug Administration (FDA).

The data in Fig. 1.3 show the number of acquired immune deficiency syndrome (AIDS) diagnoses and deaths between 1981 and 2007 in the US.

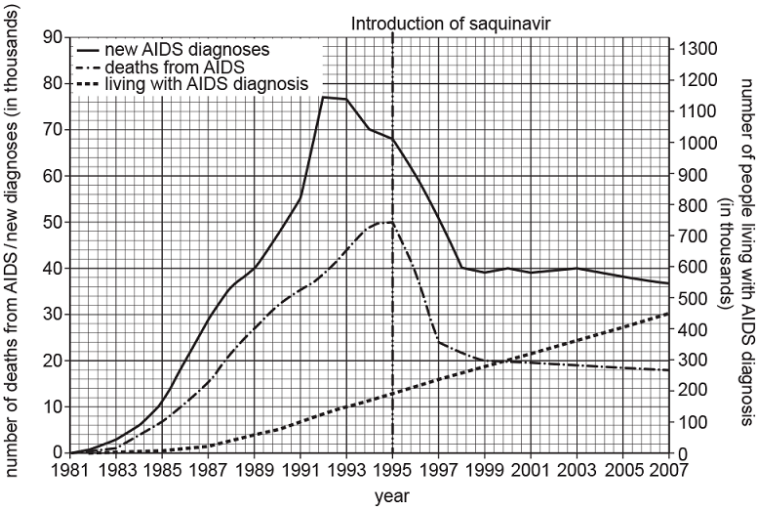

Fig. 1.3

Calculate the rate of decrease in deaths from AIDS between 1995 and 1998.

Give your answer to **two significant figures**

Show your working.

Answer ..... Units ..... **[2]**

v. A student looking at the data in Fig. 1.3 made the following conclusion:

> "The decrease in deaths from AIDS after 1995 is because of the use of saquinavir by HIV patients."

Suggest why this conclusion may be invalid based on the data in Fig. 1.3.

_____

_____

_____

_____

_____ **[2]**

81. The specific immune system is based on white blood cells called lymphocytes.

A student wrote the following passage in an essay on the immune system.

Immunisation programmes involve injecting individuals with a small amount of the safe antibody, known as a vaccine. In the UK, babies are given routine vaccinations against a range of infectious diseases including diphtheria and measles. These injections provide a form of natural passive immunity that may last a year, a few years or a lifetime.

State **three** errors that the student has made in this passage.

_____

_____

_____

_____

_____

_____ **[3]**

82(a). A program has been developed for vaccinations against the influenza virus and is updated yearly. It is recommended that the vaccination be given to adults aged 65 years and over and those under 65 years with 'at-risk' health conditions. However, not all the people in these groups take up the offer of the influenza vaccination.

The data in Fig. 4.1 show the number of influenza cases in four different environments within a single city during three consecutive winter periods from 2015–2018.

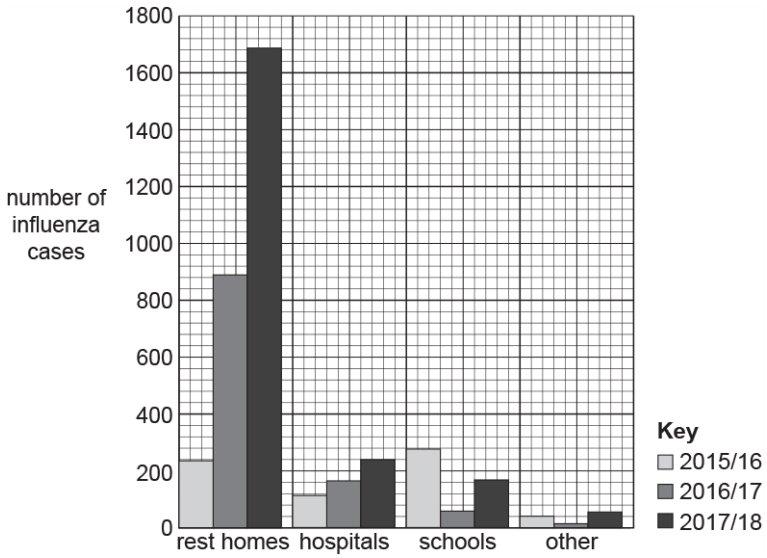

Fig. 4.1

The data in Fig. 4.2 show the percentage uptake of the influenza vaccine in four different environments in the same city during three consecutive winter periods from 2015–2018.

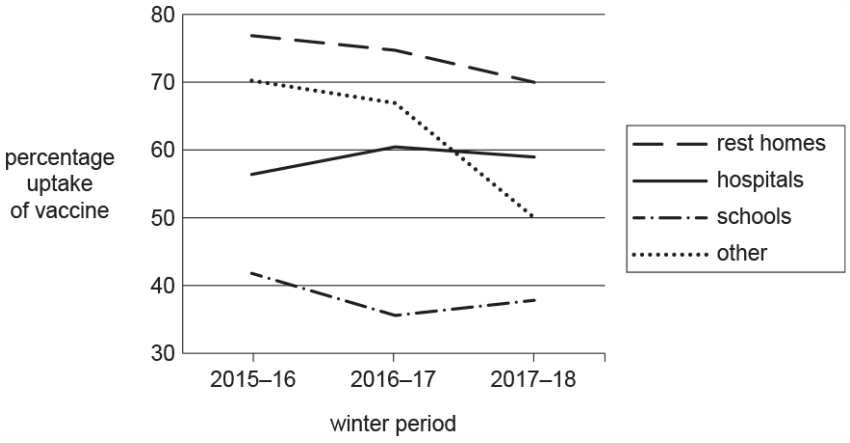

Fig. 4.2

A student looking at the data in Fig. 4.1 and Fig. 4.2 made the following conclusion:

'The data shows that a vaccination program is a successful way of reducing influenza cases in this city, as there is a direct correlation between uptake of the influenza vaccine and the number of influenza cases.'

Evaluate the validity of this statement, based on the data in Fig. 4.1 and Fig. 4.2.

_____

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_____

_____ **[4]**

(b). Complete the following sequence to outline how a vaccine gives an individual immunity.
The first two steps have been completed for you.

Step 1: A vaccine is produced that is a safe form of an antigen.

Step 2: A small amount of vaccine is injected into blood of the individual to be vaccinated.

Step 3:

_____

_____

_____

Step 4:

_____

_____

_____

Step 5:

_____

_____

_____ **[3]**

(c). Measles is a highly contagious viral infection.

In October 2018, an outbreak of the disease on the island of Madagascar resulted in more than 50 000 cases of measles. Fewer than 50% of the population was vaccinated when the outbreak began. The government of Madagascar hoped to bring the epidemic under control by vaccinating 90% of the population.

Discuss why this response was likely to bring the measles outbreak on Madagascar under control.

_____

_____

_____

_____

_____ **[2]**

83. Antibodies have a number of mechanisms of action. For example, agglutinins cause pathogens to be rendered inactive by clumping them together.

Outline the action of opsonins.

_____

_____

_____

_____

_____ **[2]**

84(a). Measles is a potentially fatal disease.

- Since 1988 children in the UK have been vaccinated against measles using the MMR vaccine.
- In 1998 a study was published which linked the MMR vaccine to the development of a condition known as autism. Some parents refused to have their children vaccinated with MMR.
- The study linking MMR to autism has since been discredited.

Table 3.1 shows some data about the percentage of children vaccinated with MMR and the incidence of measles in England and Wales.

Year	Proportion of children vaccinated with MMR (%)	Confirmed cases of measles
1997	92	177
1998	91	56
1999	88	92
2000	88	110
2001	87	70
2002	84	319
2003	82	437
2004	80	188
2005	81	78
2006	84	740
2007	85	990
2008	85	1370
2009	85	1144
2010	88	380

Table 3.1

i. Between 1997 and 1999 the mean percentage of children vaccinated with MMR was 90.3.

Calculate the mean number of confirmed cases of measles between 1997 and 1999.

Give your answer to one decimal place.

Answer…… **[1]**

ii. In 2005, despite relatively low vaccination rates, the number of confirmed cases of measles was only 78.

Use your answer to part **(i)** to calculate the percentage change in the number of confirmed cases of measles from the mean value of 1997–1999 to 2005.

Give your answer to one decimal place.

Answer…… **[2]**

iii. In early 2006, a newspaper claimed that the drop in MMR vaccination rates had not led to the predicted increase in measles cases.

Evaluate the validity of the newspaper's claim. Use processed data to support your argument.

_____

_____

_____

_____ **[3]**

(b). The MMR injection is actually a combination of three different vaccines.

It protects children against measles, mumps and rubella pathogens.

Explain why it is not possible to protect against the different pathogens using only one vaccine.

_____

_____

_____

_____ **[3]**

85. The concept of molecules with complementary shapes can be used to explain many processes in living things.

Scientists often use natural substances to help them develop specific new medicines.

State two possible sources of such natural substances.

_____

_____ **[2]**

86.

i. It takes time for an effective vaccine to be prepared in quantity for a new strain of bacterium.

List two vulnerable groups of people for whom you would advise doctors to prescribe antibiotics although they are **not** yet showing symptoms of the new disease.

_____

_____ **[2]**

ii. Discuss the implications of the over-use of antibiotics when people do not show symptoms.

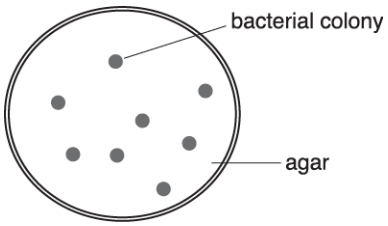
---

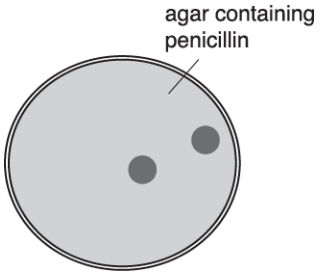
[4]

87(a). An experiment was carried out to investigate the resistance of a species of bacterium to the antibiotic penicillin.

Bacteria were allowed to grow into colonies on an agar plate.

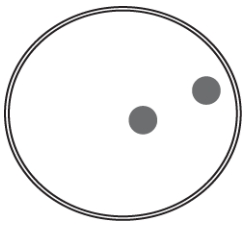
A cloth was placed onto the bacteria and then the pattern of bacterial colonies was transferred to an agar plate that contained penicillin.





Only two colonies survived and continued to grow on the agar that contained penicillin.
The bacteria in these colonies possessed a mutation that gave them resistance to the penicillin.

The original plate was flooded with a solution containing penicillin and the same two colonies continued to grow.



i. A student made the following suggestion:

> I think that the colonies on the agar containing penicillin that survived and grew did so because those bacteria evolved resistance.
> They evolved resistance as a result of being exposed to the penicillin.

Another student commented:

> But some of the bacteria in the population were already resistant, so they can't have evolved resistance because they were exposed to the penicillin.

What evidence indicates that the penicillin-resistant bacteria already existed in the population?

_____

_____

_____ **[1]**

ii. Name the process that increases the proportion of penicillin-resistant bacteria in the population.

_____ **[1]**

(b). One role of the Office for National Statistics (ONS) is to collate data about the causes of death in England and Wales. Deaths involving *Staphylococcus aureus* and MRSA statistics have been produced by the ONS for each year since 1993.

S. aureus can be mentioned on a death certificate and *S. aureus* may also be specified as being methicillin resistant (MRSA).

Table 6 shows the data for the years 1993 to 2012.

Year	Number of death certificates mentioning *S. aureus*		
	***S. aureus* not specified as resistant**	***S. aureus* specified as MRSA**	**Total**
1993	379	51	430
1994	358	90	448
1995	409	198	607
1996	445	298	743
1997	395	386	781
1998	451	409	860
1999	484	480	964
2000	476	666	1036
2001	473	731	1204
2002	421	794	1215
2003	448	968	1516
2004	461	1138	1599
2005	450	1649	2099
2006	498	1652	2150
2007	459	1593	2052
2008	270	1230	1500
2009	472	781	1253
2010	475	485	960
2011	274	364	638
2012	265	292	557

Table 6

i. Calculate the percentage increase in the number of death certificates that mention MRSA from 1993 to the year when the numbers reach a peak.

Show your working and give your answer to **three significant figures**.

Answer =..... % **[2]**

ii. The proportion of death certificates that mention MRSA in 1993 is 12%.

Compare this figure with the proportion of death certificates that mention MRSA in 2012.

[2]

iii. What can you conclude from these data about the deaths involving S. aureus and MRSA since 2007?

[2]

88. Vancomycin is an antibiotic that has been used to treat bacterial infections for many decades. Several strains of bacteria have evolved resistance to vancomycin.

Oritavancin is an antibiotic with a similar structure to vancomycin.

Table 4.2 shows data obtained from treatments with the two antibiotics.

		oritavancin	**vancomycin**
Years of use as an antibiotic		4	60
Percentage of patients developing side effects	nausea	9.9	10.5
	headache	7.1	6.7
	diarrhoea	3.7	3.2
	vomiting	4.6	4.7
	constipation	3.4	3.9
	dizziness	2.7	2.6
Percentage of bacterial infections cured	*Staphylococcus aureus*	82.5	83.5
	MRSA	81.4	80.6
	Streptococcus sp.	77.2	85.3

Table 4.2

Use the data in Table 4.2 to evaluate the advantages **and** disadvantages of using oritavancin rather than vancomycin as an antibiotic.

_____

_____

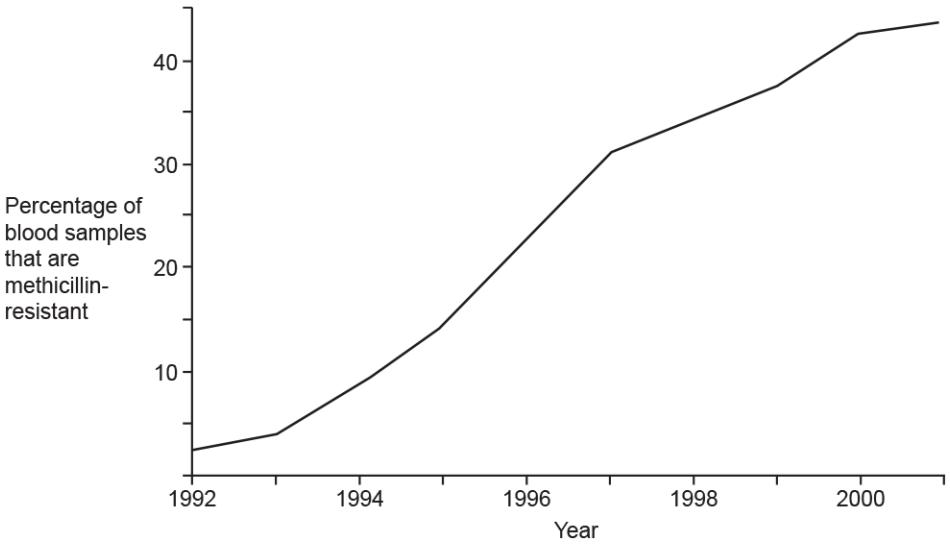
_____

_____

_____ **[2]**

89. In England and Wales, between 1992 and 2001, samples of blood were taken from patients infected with the bacterium *Staphylococcus aureus*.

The graph shows the percentage of these samples that were methicillin-resistant (MRSA).



i. Suggest explanations for the positive correlation in the data in the graph.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

ii. *Staphylococcus aureus* is the binomial name for a species of bacterium.

State **one** advantage of referring to *Staphylococcus aureus* in this way.

_____

_____ **[1]**